STORM WATER MONITORING AND BMP DEVELOPMENT STATUS REPORT

November 2004

CTSW-RT-04-069.04.05

Final Report

California Department of Transportation

Division of Environmental Analysis

1120 N Street Sacramento, California 95814

EXECUTIVESUMMARY

This report supplements the Annual Report and documents the status of the monitoring and BMP technology development. This report provides a summary of the monitoring and applied studies conducted during the 2003/2004 fiscal year and those proposed for the next three years. This report fulfills select requirements of Sections 3.3 and 7.3.1 of the Department's Statewide Storm Water Management Plan (SWMP) and Section K2 of the Department's statewide NPDES storm water permit.

The Department has an ongoing program to develop and monitor treatment and erosion control BMPs. Treatment technology pilot studies are designed to gather definitive cost and performance data. Successfully piloted technologies may be considered for approval and listing in the SWMP as a best management practice (BMP) to be implementated in highway projects according to SWMP guidelines. Erosion control studies follow a similar process. As the statewide characterization monitoring study has been completed, current storm water characterization studies are specialized to address specific concerns, such as the pathogens and first flush studies.

This report provides brief descriptions of each treatment technology study, erosion control study, and storm water characterization study; including a summary of the principal findings and conclusions to date. Treatment technology and erosion control performance results are only found in the reports for individual studies. These are listed within Sections 2 and 3. Three-Year Action Plans of expected deliverables and schedules are included for new or ongoing studies.

The status of the BMP development and monitoring studies during fiscal year (FY) 2003-04 is summarized in Table ES-1. The BMP development and monitoring studies are generally organized as completed, ongoing, new, or under report preparation. Studies in the report preparation phase have completed monitoring, but final documents are not yet available. Most applied studies during the 2003-04 monitoring season were ongoing. Table ES-1 notes the sections where more details for each study are located in this report.

Table ES-1. Status of the Department's Storm Water Monitoring and BMP Development Studies for 2003-2004

Report Section	Study Title	Study Status
2.0	**Storm Water Treatment Technology Studies**	
2.3.1	BMP Retrofit Pilot Program	Completed
2.3.2	Tahoe Basin Pilot Program	Ongoing
2.3.3	District 12 SR73 Pilot Program	Ongoing
2.3.4	District 7 Gross Solids Removal Devices (GSRDs) Pilot Program	Ongoing
2.3.5	Other Pilot Study Efforts	Ongoing
3.0	**Erosion Control Studies**	
3.3.1	District 5 Vegetation Establishment Maintenance Study (VEMS)	Ongoing
3.3.2	Soil Resource Evaluation Process	Ongoing
3.3.3	Use of Mycorrhizal Fungi in Erosion Control Applications	Ongoing
3.3.4	The Use of Amendments for Re-vegetation of Disturbed Sites with Adverse Soils	Ongoing
3.3.5	Piloting Soil Stabilization: Permanent	Ongoing
4.0	**Storm Water Quality Characterization Studies**	
4.2.1	Statewide Toxicity Testing Study	Reporting
4.2.2	Herbicide Runoff Characterization Study	Reporting
4.2.3	California Toxics Rule (CTR) Characterization Study	Reporting
4.2.4	First Flush Characterization Study	Reporting
4.2.5	Pathogens Characterization Study	Ongoing
4.2.6	District 7 Drain Inlet Cleaning Efficacy Study (litter only)	Ongoing

The Treatment BMP Technology Report (CTSW-RT-04-069.04.06) is a companion report that catalogs fact sheets for all identified storm water treatment technologies.

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Acronyms

BMP	best management practice
CDS	continuous deflection separator
CSF	Compost StormFilter ™
cfs	cubic feet per second
DB	detention basin
DII	drain inlet insert
ESSSP	East Span Seismic Safety Project
GSRD	gross solid removal device
ISD	inclined screen device
LRD	linear radial device
MEP	maximum extent practicable
mg/L	milligrams per liter
mm	millimeter
RVTS	Roadside Vegetated Treatment Sites
RWQCB	California Regional Water Quality Control Board
SFOBB	San Francisco – Oakland Bay Bridge
SR	state route
SWMP	Statewide Storm Water Management Plan
SWRCB	State Water Resources Control Board
TMDL	total maximum daily load
TRPA	Tahoe Regional Planning Agency
WQV	water quality volume

This report fulfills the Department's requirement under Section K.2 of the statewide NPDES permit 99-06-DWQ, (1 Caltrans 1999) and Section 7.3.1 of the Storm Water Management Plan (SWMP) (2 Caltrans 2003) to prepare and submit annual Storm Water Characterization Monitoring Plans, 3-Year Action Plans, and Research Summary Reports, and a Monitoring Strategy Report Update and a Monitoring and Reporting Program. The relationship between the reporting requirements and this submittal are as follows:

Table 1-1. Reporting Requirements Fulfilled by this Report

Reporting Requirements		FY 03/04
Title and location in permit, 1999	**Title and location in SWMP, May 2003**	**Section of this Report**
Monitoring Strategy Report Update (Section K.2)	N.A.	Sections 2, 3 and 4
N.A.	Storm Water Monitoring Plan: 3 Year Action Plan (Table 7-1)	Sections 2, 3 and 4
Monitoring and Reporting Program (Section K.2.a)	Storm Water Monitoring Plan: Characterization Monitoring Plan (Table 7-1)	Section 4 and Appendix A
N.A.	Storm Water Treatment Technology Research Status Report (Table 7-1)	Section 2
N.A.	Erosion Control Research Status Report (Table 7-1)	Section 3

The objectives of the Storm Water Monitoring and BMP Development Status Report is to summarize the progress of the monitoring and BMP development studies conducted during the past year and outline work proposed over the next three years. This report will be included with the submission of the Annual Report to the State Water Resources Control Board (SWRCB). Table 1-2 provides summaries of current storm water characterization studies for FY 2003-04.

This report provides brief descriptions of each storm water characterization study, treatment technology study, erosion control study and a summary of the principal findings and conclusions to date.

3-Year Action Plans of expected deliverables and schedules are included for new or ongoing studies. All Department storm water studies are performed according to specific sampling analysis plans. The sampling and analysis plan are prepared based on the guidelines provided in the Department's Comprehensive Guidance Manual (CTSW-RT-03-105-51.42). The Department has developed software and manuals (CTSW-OT-03-002) during the past four years that are consistently being used to collect representative samples, scientifically validate monitoring data, and report the data in a consistent manner. The primary application of these manuals for storm water characterization studies are briefly described in Appendix A.

The Treatment BMP Technology Report (CTSW-04-069.04.06) is a companion report that catalogs fact sheets for all identified treatment technologies.

Table 1-2. Summary of 2003-04 Storm Water Monitoring Activities

Section Number	RWQCB Region	Department District	Monitoring Sites	New or Ongoing	Target Constituents
2	**Storm Water Treatment Technology Studies**				
	Central Valley	2	I-5 PM 25.07 Partial Sedimentation Austin Sand Filter	Ongoing	NS
	Central Valley	2	Mt. Shasta Maintenance Station Full Sedimentation Austin Sand Filter	Ongoing	NS
	Lahontan	3	Hwy 50 (Near Meyers) (2) Media Filters	Ongoing	NS, Iron, Turbidity, Oil/Grease
	Lahontan	3	Small Scale Pilot Studies (at Meyers Maintenance Station)	Ongoing	NS, Iron, Turbidity, Oil/Grease
	Los Angeles	7	SR 91/Ardmore	Ongoing	Litter
	Los Angeles	7	I-405/Leadwell	Ongoing	Litter
	Los Angeles	7	I-210/Christy	Ongoing	Litter
	San Diego	11	SR 56 CDS	Ongoing	NS. Litter
	San Diego	11	SR 56 CDS	Ongoing	NS, Litter
	San Diego	12	SR 73 – Orange County Bypass Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Bypass Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Semi-Batch Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Semi-Batch Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Semi-Batch Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Semi-Batch Detention Basin	Ongoing	NS
	San Diego	12	SR 73 – Orange County Detention Basin Floating Skimmer Outlet	Ongoing	NS
	San Diego	12	SR 73 – Orange County Detention Basin Floating Skimmer Outlet	Ongoing	NS
	San Diego	12	SR 73 – Orange County Detention Basin Floating Skimmer Outlet	Ongoing	NS

Section Number	RWQCB Region	Department District	Monitoring Sites	New or Ongoing	Target Constituents
	San Diego	12	SR 73 – Orange County Detention Basin – GSRD Inlet	Ongoing	NS
	San Diego	12	SR 73 – Orange County Detention Basin – GSRD Inlet	Ongoing	NS
	San Diego	12	SR 73 – Orange County Detention Basin – GSRD Inlet	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Bypass Detention Basin	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Bypass Detention Basin	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Overflow Detention Basin	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Overflow Detention Basin	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Overflow Detention Basin	Ongoing	NS
	Santa Ana	12	SR 73 – Orange County Overflow Detention Basin	Ongoing	NS
	Santa Ana	12	SR-73 Orange County GSRD – Reverse Sloping Screen	Ongoing	NS, Litter
	Santa Ana	12	SR-73 Orange County Inclined Screen with Front-end Loader Access	Ongoing	NS, Litter
3	**Erosion Control Studies**				
	Seed Mix and Vegetation Establishment Summary				
	Central Coast	5	Cal Poly San Luis Obispo	Ongoing	TSS
	Piloting Soil Stabilization: Permanent				
	TBD	TBD	TBD	New	TBD
4	**Storm Water Characterization Studies**				
	Specialized Characterization Studies				
	San Francisco Bay	4	Southbound Hwy 680 in Solano County	Ongoing	CTR Constituents
	Santa Ana	8	Eastbound Hwy 91 in Riverside County	Ongoing	CTR Constituents
	Los Angeles	7	Drain Inlet Cleaning Efficacy Study Sites	Ongoing	Litter

NS: Normal Suite = Conventionals + Nutrients + Metals
Conventionals: DOC, TOC, Hardness, TDS, TSS, Conductivity, Temperature, pH Nutrients: Nitrate-N, TKN, Total Phosphorous, Dissolved Ortho-Phosphate
Metals: As, Cd, Cr, Cu, Pb, Ni, Zn
PM: Postmile
RWQCB: Regional Water Quality Control Board

1.1 DEVELOPING DATA FOR PROGRAM EFFECTIVENESS ASSESSMENTS

The results of these studies will help in assessing program effectiveness of BMP implementation. As assessments become more advanced, the Department will seek to quantify the benefit of BMP implementation. This requires understanding of BMP performance for pollutants of concern. This effort will follow the model currently being developed by the California Stormwater Quality Association (CASQA).

1.2 REPORT ORGANIZATION

The remaining document is organized into four sections:

Section 2 provides descriptions of activities and studies conducted as part of the Department's storm water treatment technology development program.

Section 3 provides descriptions of erosion control studies.

Section 4 provides descriptions of activities and studies conducted as part of the Department's storm water characterization program, which includes specialized characterization studies.

Section 5 contains general references. Documents specific for each study are listed within the corresponding section describing that study. The Table of Contents provides the location within this report of the various studies.

This section provides a brief summary and status of reconnaissance studies and ongoing pilot studies conducted by the Department during the past fiscal year.

2.1 PREVIOUS STUDIES

Results of treatment technology studies completed prior to July 1, 2003 are summarized in the following reports:

- Roadside Vegetated Treatment Sites (RVTS) Study, Final Report, November 2003, CTSW-RT-03-028.

2.2 LITERATURE SEARCHES AND RECONNAISSANCE STUDIES

The first step in the Department's BMP selection process is accomplished primarily through literature searches. Findings for treatment technologies are annually summarized in the Treatment BMP Technology Report (CTSW-RT-04-069.04.06), which is a companion document to this report. The second step involves performing reconnaissance studies or pilot studies for technologies (i.e., potential BMPs) that showed promise in Step 1. Reconnaissance studies are performed when additional information is required to determine whether a pilot study is worthwhile. Reconnaissance studies are more thorough engineering evaluations than Step 1, often including preliminary cost estimates. The final step, if deemed advisable after literature review or reconnaissance study, is pilot testing the technology.

2.2.1 Treatment BMP Technology Report

The Department continuously performs literature searches related to storm water treatment technology and consolidates the information in the Treatment BMP Technology Report (NTR), published annually (CTSW-RT-04-069.04.06). The NTR summarizes available design, performance and cost information and the issues and concerns that are specific to the Department's facilities for each type of storm water treatment technology identified. Appendices B and C of the NTR contain a series of fact sheets that summarize the information for each new technology. NTR Appendix B provides fact sheets on unapproved technologies that are not currently being pilot tested by the Department, while the NTR Appendix C contains fact sheets for unapproved technologies that are or have been pilot tested by the Department. Appendix D contains fact sheets of technologies approved for implementation.

2.2.2 Reconnaissance Studies

Reconnaissance studies are engineering investigations of promising technologies that are identified through the process described in Section 3.3 of the Department's SWMP. Reconnaissance studies test the viability of the technology for meeting the Department's BMP

deployment needs by considering the cost and expected performance in the Department's environment. Reconnaissance studies are often necessary precursors to further pilot testing. No reconnaissance studies were completed in the last fiscal year.

2.3 OVERVIEW OF PILOT STUDY PROGRAMS

The Department's pilot studies described in this section are being conducted under the BMP Retrofit Pilot Program, the Tahoe Basin Pilot Program, the District 12 State Route (SR) 73 Pilot Program, the Gross Solids Removal Device (GSRD) Program, and other pilot study efforts. These programs are described below. The individual pilot studies that make up each pilot program are organized by BMP type and are discussed in Sections 2.4 through 2.15.

2.3.1 BMP Retrofit Pilot Program

Detention basins, infiltration basins and trenches, wet basins, media filters, biofiltration (swales, and strips), drain inlet inserts, Continuous Deflection Separators™, oil/water separator, and multi-chambered treatment trains were installed and tested in District 7 (Los Angeles) and District 11 (San Diego). The final report is complete (CTSW-RT-01-050).

2.3.2 Tahoe Basin Pilot Program

The Tahoe Basin Program consists of both small-scale and full-scale pilot testing, as well as sand trap monitoring. A small-scale test facility has been constructed at the Department's Myers Maintenance Station in the Lake Tahoe Basin. The test facility is in its third season of operation. Two full-scale pilot systems have been constructed, and are currently being monitored. The performance monitoring program for sand traps is complete and a final report is available (CTSW-RT-03-054.36.02).

2.3.3 District 12 SR73 Pilot Program

In 2001, the Department began a pilot program along the San Joaquin Hills Transportation Corridor (SR73) in Orange County. As part of this program, operation, maintenance, and monitoring of three Compost Storm Filter Pilots was performed. A final report with the results has been prepared and is available (CTSW-RT-03-036).

Design, construction, and monitoring are currently underway for approximately 30 BMPs along SR73. The program includes 18 modified detention basins, three gross solids removal devices (GSRDs), one bioretention basin, and three sand filters.

2.3.4 District 7 Gross Solids Removal Device (GSRD) Pilot Program

The District 7 GSRD Pilot Program was initiated by the Department to develop and evaluate the performance of non-proprietary devices that can capture gross solids and that can be constructed into existing highway drainage systems or implemented in future highway drainage systems. The term "gross solids" includes litter, vegetation, and other particles of relatively large size.

2.3.5 Other Pilot Study Efforts

Other pilot study efforts include the Roadside Vegetated Treatment Sites (RVTS), San Francisco-Oakland Bay Bay Bridge pilots, District 2 Austin-Type Sand Filters and District 11 Continuous Deflection Separators.

2.4 ALTERNATIVE MEDIA FILTERS

Alternative media filters use filtration media other than sand. Alternative media have the potential to remove dissolved constituents such as metals, nutrients, and trace organics that are not removed particularly well by sand. Alternative media may be arranged in either bed or canister configurations.

2.4.1 BMP Retrofit Pilot Program — Multi-Chambered Treatment Trains (Peat/Sand Filter) and StormFilter™ (Perlite/Zeolite) Filter

The alternative media filters tested under the BMP Retrofit Pilot Program in Districts 7 and 11 use peat/sand and perlite/zeolite mixtures. The peat and sand mixture is the media used in the final chamber in the multi-chambered treatment train (MCTT). The perlite and zeolite mixture is used in the canisters in Stormwater Management, Inc.'s StormFilter™.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

The MCTT provided substantial water quality improvement and produced a very consistent, relatively high quality effluent. Although the greatest concentration reduction occurred for constituents associated with particles, substantial reduction in dissolved metals concentrations was also observed when the influent concentrations were sufficiently high, contradicting expectations that little removal of the dissolved phase would occur in this type of device. Maintenance of the filter beds to alleviate clogging was not excessive at the test sites, and the siting requirements are compatible with the small, highly impervious watersheds characteristic of Caltrans facilities. Consequently, the MCTTs were considered technically feasible.

The MCTT design incorporates permanent pools in the sedimentation chamber, which can increase vector concerns and maintenance requirements. It was found to have a similar footprint and provide a water quality benefit comparable to the Austin sand filter; however, higher life-cycle cost, and the permanent pool and associated vector issues of the MCTT suggest that in general the Austin filter would be preferred.

The Storm-Filter™ did not perform on par with other media filters tested, showing little attenuation of the peak runoff rate and producing a reduction in most constituent concentrations that was not statistically significant. In addition, the standing water in the Storm-Filter™ has the potential to breed mosquitoes. Although technically feasible at the piloted location, the Storm-Filter™ pollutant removal was less and its life-cycle cost was more than the Austin sand filter. Therefore, the Storm-Filter™ will not be considered to be preferable for use at Caltrans facilities based on the media evaluated in this study, even if the vector problems were avoided.

Maintenance and operation of pumps at several sites was a recurring problem. Consequently, other technologies should be considered at sites with insufficient hydraulic head for operation of media filters by gravity flow.

Future research on construction methods and materials for sand filters is needed to improve the cost/benefit ratio for these devices. In addition, evaluation of alternative media may also allow the targeting of specific constituents or improvement in the performance for soluble constituents, such as nitrate, which are not effectively removed by a sand medium. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004

2.4.2 Tahoe Basin Pilot Program — Small-Scale Pilot Studies

Objectives

The Tahoe small-scale pilot treatment systems operate intermittently to treat discrete batches of storm water collected after various runoff events. Objectives of these pilot studies include:

- Testing the effectiveness of sedimentation and media filtration treatment systems in removing colloidal, dissolved and particulate storm water pollutants
- Developing design parameters for full-scale pilots

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
Meyers Maintenance Station, Lahontan, D-3	Varies	Third monitoring season (03/04) testing complete. Third monitoring season report anticipated in 2004.

Findings/Conclusions

First and second monitoring season reports are now complete. First season monitoring showed that the filtration systems tested, with the possible exception of activated alumina filtration, were ineffective when used without prior chemical addition and sedimentation. Second season monitoring and testing showed that filtration through activated alumina and expanded shale, following 24-hour sedimentation without chemical addition, almost always met the required surface water discharge limits. However, both media, expanded shale in particular, increased effluent pH and dissolved aluminum concentrations. Sedimentation without chemicals followed by fine sand filtration was found to be ineffective as a treatment system for the Tahoe Basin. Third monitoring season objectives include breakthrough testing to determine expected life of activated alumina, expanded shale, and other media.

Available Documents

Department Document No.	Document Title
CTSW-RT-01-054-D	Lake Tahoe Storm Water Treatment Pilot Project Monitoring and Operations Plan. October 2001.
CTSW-RT-03-042	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase I Report.
CTSW-RT-03-053.33.41	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase II Monitoring and Operations Plan. June 2003.
CTSW-RT-03-079.31.37	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase II Report.

CTSW-RT-04-069.04.04	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase III Monitoring and Operations Plan. June 2004.

3-Year Action Plan

Overview of Approach

The study will continue with media that has shown the most promise based on past results. Both 4-inch and 30-inch columns will be used to test removal efficiencies for different concentrations, chemical additions, media, detention times, and volumes treated.

Products or Deliverables

- Reconnaissance study or other literature review reports
- Site-specific Monitoring and Operations Plans
- Final reports summarizing and analyzing data collected

Schedule

Monitoring will likely continue for the next three years. Annual or interim reports will be prepared to document specific reports.

2.4.3 Tahoe Basin Pilot Program — Large-Scale Pilot Studies

Two full-scale BMPs have been constructed using activated alumina as the filter media. Activated alumina showed some promise for removing nutrients from storm water when tested in the small-scale pilot facility. Both filters are modeled after Austin-style sand filters, but have twelve inches of activated alumina overlain by six inches of sand rather than the typical 18-inch layer of sand.

Objectives

These pilots were designed to determine:

- The effectiveness of activated alumina in removing nutrients and solids
- The hydraulic performance of the BMP in the alpine climate
- The maintenance requirements
- Construction and maintenance cost

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
HWY 50, Lahontan, D-3	2	Construction complete, monitoring is ongoing. Final report anticipated in 2007.

Findings/Conclusions

None

Available Documents

None

3-Year Action Plan

Products and Deliverables

Interim data reports should be produced at the end of each sampling year, while a final report will be produced when the study is complete.

Schedule

Monitoring will continue during the 04/05, and beyond, depending on storm capture success.

2.5 BIORETENTION

Bioretention refers to a system in which storm water is captured and infiltrated in a shallow, offline, vegetated basin. Storm water pollutants are removed through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization. Bioretention facilities typically include a pretreatment biofilter (vegetated swale or strip) to reduce velocities and filter out particulates, a sand trench to augment the infiltration capacity of the planted bed and to evenly distribute incoming runoff and a ponding area to collect and store runoff prior to infiltration. Sometimes an underdrain system is provided to capture and transport the infiltrated runoff.

2.5.1 San Francisco–Oakland Bay Bridge — Bioretention

As part of the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project (ESSSP), the Department is proposing to treat storm water on the eastern portion of the ESSSP (i.e., Oakland Approach) and the SFOBB Toll Plaza using bioretention filters and other approved BMPs.

Objectives

This pilot is designed to determine:

- Effectiveness of the bioretention filter in removing constituents of concern
- Construction costs
- Operations and maintenance costs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
I-80, San Francisco, D-4	2	In design. Final report anticipated in 2010.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
not available	Engineering Design of Storm Water Treatment BMPs for Oakland Bay Bridge Approach. Basis of Design Report.

3-Year Action Plan

Overview of Approach

- Prepare sampling and analysis plans (SAP).
- Perform in and out water quality monitoring.
- Prepare a Final Report documenting performance and cost.

Products or Deliverables

- As-builts
- SAP
- Monitoring Reports
- Final Report

Schedule

Construction is not expected until Fall 2005.

2.5.2 District 12 SR73 Pilot Program — Bioretention

Objectives

The Department will be replacing an existing CSF and basin along the San Joaquin Hills Transportation Corridor (SR73) with a bioretention filter. Siting and design of the bioretention filter is complete.

These pilots are designed to determine:

- Effectiveness of the bioretention filter in removing constituents of concern
- Construction costs
- Operation and maintenance costs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR 73, Santa Ana, D-12	1	Design complete. Estimated completion Winter 2005. Final report anticipated in 2008.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-RT-03-006.51.39	Basis of Design report, SR-73 Storm Water BMP Replacement Project at CSF System 1149L Bioretention Area, November 2003

3-Year Action Plan

Overview of Approach

- Prepare sampling and analysis plans (SAP).
- Perform in and out water quality monitoring.
- Prepare a Final Report documenting performance and cost.

Products or Deliverables

- As-builts
- SAP
- Monitoring Reports
- Final Report

Schedule

Sampling and analysis plans are to be developed in 2004/05. Construction will begin Fall 2004. Monitoring should begin in 2005/06.

2.6 CHEMICAL TREATMENT

Chemical addition is intended to improve phosphorus and particulate removal (by precipitation and coagulation followed by settling) or as a filter aid to improve filtration performance.

2.6.1 Tahoe Basin Small-Scale Test Facility — Small-Scale Pilot Studies

Objectives

The objectives of testing chemical treatment systems are to determine:

- Effectiveness of chemical addition for improving pollutant removal
- Appropriate chemical additive doses for storm water treatment
- Sensitivity of performance to dose to determine technical feasibility of dosing variable flows
- Negative impacts to water quality due to added chemicals

Current Status

A number of chemicals have been tested in jar test and/or settling rate experiments, including PASS-C® and PAX-XL9® (both polyaluminum chlorides), PAM, and chitosan (a naturally

occurring biopolymer). The "mechanized" systems tested included proprietary high-rate Actiflo® clarification and non-proprietary conventional clarification with PASS-C®.

Location (Route, RWQCB, District)	No. of Pilots	Status
Meyers Maintenance Station, Lahontan, D-3	Varies	Third monitoring season (03/04) testing complete. Third monitoring season report expected in 2004.

Findings/Conclusions

First and second monitoring season reports are now complete. First season monitoring (01/02) showed the effectiveness of PASS-C®-assisted sedimentation. Second season (02/03) testing with PASS-C® and liquid chitosan suggested that chemical treatment followed by sedimentation alone may be sufficient to meet the surface water discharge limits in some situations. PASS-C addition, however, lowers effluent pH, sometimes to below 6.5. Both the proprietary and non-proprietary mechanized systems met all the surface discharge standards in all the second monitoring season experimental runs. Third season monitoring objectives included settling rate experiments with PASS-C®, PAX-XL9® and chitosan to determine overall treatment effectiveness at optimized doses.

Available Documents

Department Document No.	Document Title
CTSW-RT-01-026	Chemical Treatment to Improve Settling Reconnaissance Study.
CTSW-RT-01-054-D	Lake Tahoe Storm Water Treatment Pilot Project Monitoring and Operations Plan. October 2001.
CTSW-RT-03-042	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase I Report.
CTSW-RT-03-053.33.41	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase II Monitoring and Operations Plan. June 2003.
CTSW-RT-03-079.31.37	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase II Report.
CTSW-RT-04-069.04.04	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase III Monitoring and Operations Plan. June 2004.
CTSW-RT-03-063.33.41	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Jar Test Results and SummaryReport
CTSW-RT-01-026	Chemical Treatment to Improve Settling Reconnaisance Study.

3-Year Action Plan

Overview of Approach

- Literature searches and reconnaissance studies for selection of promising chemicals
- and chemical applications method
- Selection of pilot treatments systems for testing
- Development of a site-specific Monitoring and Operations Plan
- Design, construction and modification of new and existing pilot systems
- Operation, maintenance and monitoring

Products and Deliverables

- Reconnaissance study or other literature review reports
- Site-specific Monitoring and Operations Plans
- Post-storm technical memoranda
- Final reports summarizing and analyzing data collected

Schedule
See Section 2-17.

2.7 CONSTRUCTED WETLANDS

Constructed wetlands are basin-type technologies that use wetland vegetation and shallow, distributed flow to encourage settling and nutrient uptake. Design guidance varies significantly, but in many cases constructed wetlands capture less volume than detention basins are designed to capture. As such, constructed wetlands act more as flow-through treatment devices than as capture-and-release devices.

2.7.1 District 12 SR-73 Pilot Program- Constructed Wetlands

After further review of existing design, Basin 765L, located on El Toro Road, will not be monitored. Monitoring the existing design would not yield useful information for future applications. A GSRD will be installed (see section 2.11.3).

2.8 DRAIN INLET INSERTS

Drain inlet inserts (DII) are devices designed for installation within existing storm drain inlets, without a need for significant modification of the inlets.

2.8.1 BMP Retrofit Pilot Program — Drain Inlet Inserts

The BMP Retrofit Pilot Program pilot DIIs were located in typical maintenance station drainage areas. The technology was not sited for roadside conditions to avoid maintenance adjacent to the traveled way. StreamGuard® DII is a sock-type unit that friction-fits by the weight of the drain inlet grate (shims were required). FossilFilter® is a perimeter tray-type unit that is installed along each effective edge of a drain inlet. The trays contain filtration media (alumina silicate) to aid in pollutant removal.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

Two models of proprietary drain inlet inserts were evaluated. The data collected during this study indicate that they cannot be operated unattended because of hydraulic limitations that resulted in flooding on a number of occasions and clogging that caused bypass of untreated runoff. Their pollutant removal was also minimal. The absolute number of maintenance hours was not large; however, the timing of maintenance was critical, right before and during storm events. Because of their frequent maintenance requirements and safety considerations (access along active freeways and highways), implementation on roadsides would not be appropriate. Installation at maintenance stations might be considered safer; however, timely maintenance is often infeasible due to other maintenance activities required during storm events. In addition, they were only marginally effective, with constituent removal generally less than 10 percent. Consequently, these particular models were judged to be not technically feasible at the piloted locations.

The two types of inserts monitored in this study were carefully selected from the many types that were available at the start of the study based on an evaluation of their water quality improvement potential. There are many other types of proprietary drain inlet inserts on the market that were not evaluated and may perform better than the two evaluated here; however, until there is better independent documentation of their pollutant removal effectiveness as well as operation and maintenance requirements, this technology should not be routinely considered for

implementation. The variety of drain inlet inserts on the market has increased since the beginning of the pilot program, and one of the inserts evaluated during this study is no longer being manufactured. Some newer insert types are now available but the results of this study should not be used to assess the expected feasibility and/or performance of these recently available technologies. It should be noted trash removal was not monitored as part of this study and certain types of drain inlet inserts may be effective for this purpose. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.9 DETENTION BASINS

Detention basins (DBs) temporarily store water to allow solids and associated pollutants to settle out. Storage is achieved by limiting the rate of flow out of the basin, typically through the use of small (approximately 1-inch diameter) orifices on an outflow riser. Runoff volumes greater than the predetermined design storm water quality volume (WQV) are either routed around the basin or through the basin via an overflow weir or standpipe.

2.9.1 BMP Retrofit Pilot Program — Detention Basins

The BMP Retrofit Pilot Program pilot DBs were sized to detain the design storm WQV and release it through small orifices over a period up to 72 hours.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

Extended detention basins have an especially extensive history of implementation in many areas and are recognized as one of the most flexible structural controls. The pollutant removal observed in the extended detention basins was similar to that reported in previous studies (Young, 1996) and appeared to be independent of length/width ratio, which is a commonly used design parameter. Resuspension of previously accumulated material was more of an issue in the concrete-lined basin, which exhibited less constituent concentration reduction than in-situ, earthen designs. Based on these findings, unlined extended basins are preferred except where potential groundwater contamination is an over-riding concern.

There are few constraints for siting extended detention basins, although larger tributary areas can reduce the unit cost and increase the size of the outlet orifices, making clogging less likely. The relatively small head requirement (as compared to Austin sand filters) associated with this technology is particularly useful in retrofit situations where the elevation of existing stormwater infrastructure is a design constraint. The unlined installations in southern California did not experience any problems associated with establishment of wetland vegetation, erosion or excessive maintenance (as compared to the lined basin). Except where groundwater quality may be impacted, unlined basins are preferred on a water quality basis because of the substantial infiltration and associated pollutant load reductions that were observed at these sites.

This study reaffirms the flexibility and performance of this conventional technology and confirms their technical feasibility, depending on site specific conditions. The effectiveness, small head requirement and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment at Caltrans facilities. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.9.2 District 12 SR73 Pilot Program — Bypass Detention Basins

Existing SR73 equalization basins have been modified to evaluate the effect that decreasing the basin volume has on detention times and pollutant removal abilities of bypass DBs. Bypass DBs use a splitter box upstream of the basin to divert water around the basin once a predetermined

basin depth is reached. In this study, basins were sized at approximately 100, 75, 50 and 25 percent of the design storm WQV. Coincident to this study, three other studies will allow comparison of bypass-type operation with overflow-type operation, "semi-batch" operation, and surface drained (skimmer). (See sections 2.10.3-2.10.5.)

Objectives

These pilots are designed to determine:

- Relationships between basin volume, detention time and removal efficiency (or irreducible concentration) in bypass DBs
- Construction costs in the Department's retrofit environment
- Operation and maintenance costs
- How the performance of bypass DBs compares to that of overflow, surface drained, and semi-batch DBs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR73, San Diego and Santa Ana, D-12	4	Construction complete. Water quality monitoring to start in 2004/2005 wet season. Final report anticipated in 2008.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-RT-01-029	Detention Basin Optimization-Reconnaisance Study Final Report

3-Year Action Plan

This three-year action plan covers all of the bypass, overflow, surface drained, and semi-batch basins.

Water quality and operational monitoring will be conducted for at least two wet seasons (04/05 and 05/06). A final report will be produced after enough data has been gathered to make statistically significant determinations regarding performance.

Products and Deliverables

A Final Report will be produced, likely in 2008.

Schedule

2004/05	Operational monitoring only
2004 - 2007	Operational and water quality monitoring.
2008	Production of final report.

2.9.3 District 12 SR73 Pilot Program — Overflow Detention Basins

Existing SR73 equalization basins have been modified to evaluate the effect of decreasing the basin volume on detention times and pollutant removal abilities of overflow DBs. In overflow DBs, water in excess of the design WQV will flow into the basin and out over a flood control weir or standpipe. Basins will be sized at approximately 100, 75, 50 and 25 percent of the design storm volume.

Objectives

These pilots are designed to determine:

- Relationships between basin volume, detention time and removal efficiency (or irreducible concentration) in overflow DBs
- Construction costs in the Department's retrofit environment
- Operation and maintenance costs
- How the performance of overflow DBs compares to that of bypass, surface drained, and semi-batch DBs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR73, Santa Ana, D-12	4	Construction complete. Water quality monitoring to start in 2004/2005 wet season. Final report anticipated in 2008.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-RT-01-029	Detention Basin Optimization-Reconnaisance Study Final Report

3-Year Action Plan

See the three-year action plan for bypass detention basins.

2.9.4 District 12 SR73 Pilot Program — Semi-Batch Detention Basins

Existing SR73 equalization basins are being modified to evaluate the effects of semi-batch operation and varying pond volume on detention time and pollutant removal efficiency. Semi-batch operation (also called hold-and-release) is achieved by installing a valve on the outlet of an overflow DB. During storms, when the basin begins to fill, the valve closes. This creates a quiescent pool that is expected to improve settling by retarding water movement. After some chosen time (e.g., 24 hours) has elapsed, the valve will open and the basin will drain like a normal DB. Inflow in excess of the pond design volume will overflow a weir. Like the bypass and overflow basins, the semi-batch basins will be sized at approximately 100, 75, 50 and 25 percent of the design storm WQV.

Objectives

These pilots are designed to determine:

- Technical feasibility of various hold-and-release valves
- Relationships between basin volume, detention time and removal efficiency (or irreducible concentration) in semi-batch DBs
- Construction costs in the Department's retrofit environment
- Operation and maintenance costs
- How the performance of semi-batch DBs compares to that of bypass, overflow, and surface drained DBs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR73, San Diego, D-12	4	Construction is complete. Water quality monitoring to start in 2004/2005 wet season. Final report anticipated in 2008.

Findings/Conclusions

Available Documents

Department Document No.	Document Title
CTSW-TM-01-005	Inlet/Outlet Alternatives For Extended Detention Basins Technical Memorandum.

3-Year Action Plan

See the three-year action plan for bypass detention basins.

2.9.5 District 12 SR73 Pilot Program — Surface Drained Detention Basins (Floating Skimmer Outlet)

Objectives

Existing SR73 equalization basins are being modified with floating skimmer outlets to determine if decanting water from the top of a detention basin rather than the bottom improves pollutant removal. The outflow skimmer is composed of a float and an attached pipe with orifices. Inflow in excess of the WQV will overflow a weir.

These pilots are designed to determine:

- Technical feasibility of floating skimmers
- Relationships between basin volume, detention time and removal efficiency (or irreducible concentration) while using a floating skimmer
- Construction costs in the Department's retrofit environment
- Operation and maintenance costs
- How the performance of surface drained DBs compares to that of bypass, overflow, and semi-batch DBs.

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR73, San Diego, D-12	4	Construction on three of the basins are complete. The fourth basin is being redesigned due to conflicts with a ramp realignment project that is now complete. Final report anticipated in 2008.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-TM-01-005	Inlet/Outlet Alternatives For Extended Detention Basins Technical Memorandum.

3-Year Action Plan

See the three-year action plan for bypass detention basins.

2.9.6 District 12 SR73 Pilot Program — Alternative Inlet

Objectives

Existing SR73 equalization basins will be retrofit with the Department's linear radial GSRD to examine the improvement to water quality and the effect on maintenance costs associated with dissipating flow energy and capturing litter as it enters a detention basin. Three linear radial GSRDs are being tested.

These pilots are designed to determine:

- Technical feasibility of using a linear radial GSRD to dissipate flow energy
- Technical feasibility of using a linear radial GSRD to trap litter in a detention basin
- Construction costs in the Department's retrofit environment
- Operation and maintenance costs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR73, San Diego, D-12	2	Construction complete. Final report anticipated in 2008.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-TM-01-005	Inlet/Outlet Alternatives For Extended Detention Basins Technical Memorandum.

3-Year Action Plan

See the three-year action plan for District 12 SR73 Pilot Program — GSRDs (Section 2.10.3).

2.10 GROSS SOLIDS REMOVAL DEVICES

GSRDs include physical/mechanical methods of removing litter and solids five millimeters (mm) (0.25-inch nominal) and larger from the storm water runoff using various screening technologies. The objective of the GSRD pilots is to test end-of-pipe treatment devices that can be incorporated into existing or future highway drainage systems to capture litter and other coarse solids (collectively known as "gross solids").

2.10.1 BMP Retrofit Pilot Program — Continuous Deflection Separators

A continuous deflection separator (CDS) unit is a cylindrical device with an inner cylinder made of a steel screen inside a cylindrical fiberglass housing. Water is introduced tangentially into the inner cylinder and solids are deflected off the screen until they fall into a sump located beneath the cylinder. The screened water flows through the perforations and into the larger housing where it exits the device over a weir. The CDS unit being tested is designed for flows up to 1 cubic foot per second (cfs).

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

Two CDS® units were successfully sited, constructed and monitored during the study. The devices were developed in Australia with the primary objective of gross pollutant (trash and litter) removal from stormwater runoff. The devices are considered technically feasible depending on site specific conditions. They were highly successful at removing gross pollutants, capturing an average of 88 percent, with bypass of this material occurring mainly when the flow capacity of the units was exceeded. Even though these two units were sited on elevated sections of freeways, 94 percent of the captured material by weight was vegetation. Consequently, the maintenance requirements may be excessive if these units are located in an area with a significant number of trees or other sources of vegetative material.

A secondary objective of the CDS® units is the capture of sediment and associated pollutants, particularly the larger size fractions. The average sediment concentration in the influent to the two systems was relatively low and no significant reduction was observed. Reductions in the concentrations of other constituents were also not significant. It should be noted that the specific fiberglass CDS® units tested in this study are no longer offered by the manufacturer. CDS® does manufacture similar concrete units that were not evaluated as a part of this study.

These devices maintain a permanent pool in their sumps and mosquito breeding was observed repeatedly at the two sites. The frequency of breeding was reduced by sealing the lids of the units and installing mosquito netting over the outlet. Other non-proprietary devices developed by Caltrans for litter control, which do not maintain a permanent pool, may be preferred to this technology to minimize vector concerns. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.10.2 District 7 GSRD Pilot Program

Objectives

The District 7 GSRDs were developed to help meet the requirements of the Los Angeles RWQCB's adopted total maximum daily load (TMDL) for the Los Angeles River. Nine different types of GSRDs are being tested in the Los Angeles River watershed in District 7. The GSRD names are in the following lists and descriptions are in the following text.

Linear Radial Devices (LRD):

- LR1 Configuration 1 – louvered well casing
- LR2 Configuration 2 – wire mesh screens with nylon mesh bags

Inclined Screen Devices (ISD):

- IS1 Configuration 1 – parabolic wedge wire screen
- IS2 Configuration 2 – parabolic wedge wire bars
- IS3 Configuration 3 – parabolic wedge wire screen (front-end loader)
- IS4 Configuration 4 – wedge wire screen, direct flow

Baffle Box (BB)

V-screens (VS):

- VS1 Configuration 1 – forward sloping screen (FSS)
- VS2 Configuration 2 – reverse sloping screen (RSS)

Linear Radial Device (LRD) – Configuration 1 uses modular well casings with 5-mm (0.25-inch nominal) louvers to remove litter. Flow enters the casing and passes radially through the louvers, trapping litter and solids inside. The clean water flows into a vault holding the GSRD and is directed to an outlet pipe. Access doors are provided on the well casings for ease of maintenance and cleaning using a vacuum truck. Configuration 2 uses modular well casing with 5 mm x 5 mm rigid mesh screen housing. Inside the screen are nylon mesh bags with 5 mm openings that capture gross solids.

Inclined Screen Device (ISD) – In Configuration 1, flow overtops a weir and falls through an inclined wedge wire screen with 3 mm spacing. Litter stopped by the screen falls or is pushed down the face of the screen into a litter storage area. The litter storage area is sloped and is provided with a drain to prevent standing water. Configuration 2 uses wedge wire bars with 5 mm spaces. Configuration 3 is the same as Configuration 1, except it has access for cleaning by a front-end loader. Configuration 4 contains a straight screen rather than a curved one; and runoff discharges onto the screen at a single point instead of being uniformly distributed across the width of the bar rack by an influent trough.

Baffle Box–This device applies a two-chamber concept. The first chamber utilizes an underflow weir and 50-mm screen to trap floatable litter. The second chamber uses a 5-mm screen to capture materials that get past the underflow weir and 50-mm screen. Once the flow enters this device, reduced velocities allow solids to settle. Peak flow velocities are maintained at levels that will not re-suspend solids. Litter entering the device generally floats; however, some will eventually settle. Storage is provided for both floatable and settleable litter.

V-screens – Configuration 1 is an open-ended concrete box with a wedge wire, v-shaped bar rack. The v-shaped bar rack is placed directly in front of a discharge pipe with the vertex of the

"v" along the centerline of the inlet pipe. The bar rack diverts litter toward the sides of the concrete box. The bar rack is also at a positive inclination; that is, the top of the bar rack is slightly farther away from the incoming flow than the bottom of the bar rack. The difference between Configuration 1 and Configuration 2 is the positive or negative inclination of the bar rack. Configuration 2 contains a bar rack at a negative inclination, that is, the bottom of the bar rack is slightly farther away from the incoming flow than the top of the bar rack.

These pilots are designed to determine:

- Effectiveness of GSRDs in removing gross solids
- Construction costs
- Operation and maintenance costs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR 91/Ardmore, Los Angeles, D-7	1 V-Screen – Conf. 2	Construction complete. Final report anticipated in 2006.
1-405/Leadwell, Los Angeles, D-7	1 V-Screen – Conf. 1	Construction complete. Final report anticipated in 2006.
1-210/Christy, Los Angeles, D-7	1 Inclined Screen – Conf. 4	Construction complete. Final report anticipated in 2006.

Findings/Conclusions

The Linear Radial Configuration 1 and Inclined Screen Configuration 1 were determined to be effective at removing gross solids from storm water runoff. The Linear Radial Configuration 2, Inclined Screen Configuration 2, and the Baffle Box were determined to be either too maintenance intensive or ineffective. As a result, these devices have been removed from further consideration. The Inclined Screen Configuration 3 proved to be a valid design concept. However, a re-design has been recommended to eliminate the intensive maintenance requirements that were documented throughout the study period. The remaining GSRDs are still under evaluation.

Available Documents

Department Document No.	Document Title
CTSW-RT-03-072.31.22	Phase 1 Gross Solids Removal Devices Pilot Study: 2000-2002. Final Report October 2003.
CTSW-RT-01-005	Preliminary Design Report: Litter Solids Removal Device. January 2001
CTSW-RT-01-047	Gross Solids Removal Device Pilot Study 2000-2001 Interim Report.

Department Document No.	Document Title
CTSW-RT-01-004	Sampling and Analysis Plan: Litter Solids Removal Device Pilot Study. January 2001.
CTSW-RT-03-099.31.24	Phase III Gross Solids Removal Devices Pilot Study: 2002-2003 Interim Report. November 2003.
CTSW-RT-03-098.31.17	Phase III Gross Solids Removal Devices Basis of Design Report. November 2003.
CTSW-RT-03-077.31.24D	Phase IV Gross Solids Removal Devices, Operations, Maintenance, and Monitoring Plan. Monitoring Season 2003-2004. September 2003.
CTSW-RT-02-071	Phase II & III Gross Solids Removal Devices , Operations and Maintenance Plan Monitoring Season 2002-2003. November 2002
CTSW-RT-03-097.31.22	Phase II Gross Solids Removal Devices Pilot Study: 2001-2003. Final Report November 2003.
CTSW-RT-01-069	Basis of Design Report: Gross Solids Removal Device Pilot Study, Phase II. November 2001.

3-Year Action Plan

Overview of Approach

Continue operation and monitoring per established plans.

Products and Deliverables

Produce a final report for continuing pilots.

Schedule

Monitoring will begin in the 2004/2005 wet season and the final report will be available in 2006.

2.10.3 District 12 SR73 Pilot Program — GSRDs

Objectives

In response to Cease and Desist Order No. 2001-198 issued by the San Diego RWQCB, the Department will be replacing four existing CSFs along the San Joaquin Hills Transportation Corridor (SR73) with GSRDs. One of these sites will include a GSRD with reverse sloping screen downstream of inflow pipe, creating a large area for storage of gross solids. Energy dissipater blocks will be constructed downstream of the screen to slow the flow and allow settling in a sedimentation area. The second site will have an inclined screen with front-end

loader access upstream of a detention basin. The third site will be an FSS GSRD. The fourth is undergoing design.

These pilots are designed to determine:

- Effectiveness of GSRDs in removing gross solids
- Construction costs
- Operations and maintenance costs

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR-73, Santa Ana, D-12	1 V-screen Configuration 1	GSRD on Basin 1085L: Construction complete. Final report anticipated in 2006.
SR-73, Santa Ana, D-12	1 Inclined Screen Configuration 3	GSRD on basin 1180R: Construction complete. Final report anticipated in 2007.
SR-73, San Diego, D-12	1 V-screen Configuration 2	GSRD on basin 630L: Awaiting construction. Estimated date of completion of construction Spring 2005. Final report anticipated in 2006.
SR-73, San Diego, D-12	TBD	GSRD on Basin 765L: Undergoing design. Construction expected Spring 2006. Final report anticipated in 2009.

Findings/Conclusions

None

Available Documents

Department Document No.	Document Title
CTSW-RT-03-121.31.10	SR-73 Storm Water BMP Replacement Project at CSF System 1085L and 630L Gross Solids Removal Device. Basis of Design Report December 2003.
CTSW-RT-03-030	SR-73 1085L GSRD with Sediment Trap, Operations, Maintenance, and Monitoring Plan Monitoring Season 2002-2003. January 2003.
CTSW-RT-03-120.31.25	SR-73 Storm Water BMP Replacement Project at CSF System 1085L GSRD Interim Report. December 2003.

3-Year Action Plan

Overview of Approach

Continue monitoring devices for litter loading rates, maintenance requirements, and operational problems.

Products and Deliverables

Final report on cost, performance, and maintenance requirements.

Schedule

Monitoring should continue through the 04-05 wet season. The final report will be prepared in FY 05-06.

2.10.4 District 11 — Continuous Deflection Separators

The Department's District 11 has installed two CDS® units on SR-56. Sorbent material (sand) was inserted in these units to reduce discharges of oil and grease from the highway surface. These CDS® units also have weep holes at the bottom to facilitate drainage of standing water.

Objectives

These pilots are designed to determine:

- Effectiveness of CDS in removing pollutants of concern
- Effectiveness of weep holes in draining standing water

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR-56, San Diego, D-11	2	Second year monitoring (03/04) is complete. Water quality monitoring to continue in following three wet seasons. Final report anticipated in 2009.

Findings/Conclusions

Weep holes did not work to prevent standing water.

Available Documents

Department Document No.	Document Title
CTSW-RT-03-121.650.05	SR-56 CDS® and receiving water monitoring

3-Year Action Plan

Overview of Approach

Continue monitoring per agreement with the San Diego RWQCB.

Products and Deliverables

Final Report on performance expected in 2009.

Schedule

Monitoring will continue through the 2006/2007 wet season.

2.10.5 Laboratory Testing of Gross Solids Removal Devices

Objectives

These pilots are designed to determine the hydraulic performance of the proposed devices under different flow rates and debris-loading conditions. The results of these tests will help with the creation of standard specifications for Caltrans engineers.

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
UC Davis Hydraulic Lab	3	Tests are ongoing.

Findings/Conclusions

None

Available Documents

None

3-Year Action Plan

Overview of Approach

Conduct flow tests with different flow rates, slope and solids loadings through 2005.

Products and Deliverables

Final Report expected in 2005.

Schedule

Laboratory tests will continue through 2005. A final report is expected in 2005.

2.11 INFILTRATION

Infiltration technologies temporarily store water and cause it to infiltrate into the soil. Runoff volumes greater than the predetermined design WQV are typically routed around infiltration devices.

2.11.1 BMP Retrofit Pilot Program — Infiltration Basins and Trenches

The BMP Retrofit Pilot Program pilot infiltration devices were constructed at both highway and maintenance station sites. Infiltration basins are shallow enough to infiltrate the capture volume within 72 hours to comply with California State Department of Health requirements on vector control. Design drain time is shorter to allow for a factor of safety. Infiltration trenches are backfilled with porous media (typically large rock). The trench is sized to completely capture the design WQV within the pore space of the backfill media.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

Infiltration basins and trenches are considered be technically feasible depending on site specific conditions. However, there are three main constraints to widespread implementation of infiltration devices: locating sites with appropriate soils, the potential threat to groundwater

quality, and the risk of site failure due to clogging. Further investigation of these constraints is recommended.

Infiltration basins and trenches can be an especially attractive option for BMP implementation, since they provide the highest level of surface water quality protection. In addition, they reduce the total amount of runoff, restoring some of the original hydrologic conditions of an undeveloped watershed. Although trenches and basins are similar in terms of their water quality benefits, the siting and maintenance requirements of the two devices are distinctly different. Infiltration basins generally treat runoff from relatively larger tributary areas and require more routine maintenance such as vegetation management, but they are easier to rehabilitate when clogged. Conversely, infiltration trenches generally treat runoff from smaller areas, and their smaller footprint allows them to be sited in more space-constrained areas. Observed routine maintenance was less; however, once clogged, partial or complete reconstruction may be required, resulting in uncertain long-term cost.

The original siting study did not identify sufficient suitable locations for the number of infiltration installations specified in the District 7 Stipulation within the time frame provided in the agreement. This study is being followed by assessments in both Districts to gauge the potential extent of infiltration opportunities. In Los Angeles, the assessment is being accomplished with field investigations in selected highway corridors and in San Diego by existing data, but more broadly based through the District. In addition, there is concern at the state and regional levels about the impact on groundwater quality from infiltrated runoff. The portion of this study that was implemented to assess the potential impact to groundwater quality from infiltrated stormwater runoff was largely unsuccessful and longer term, more comprehensive studies than were possible under this pilot program are warranted. Despite these uncertainties, the parties in this study worked cooperatively to develop interim guidelines for siting infiltration devices in response to requests by the State and Regional Water Quality Control Boards.

In summary, infiltration can be a more challenging technology in that site assessment, groundwater concerns, and long-term maintenance issues are important elements that are subject to some uncertainty. The experience in this study is that siting these devices under marginal soil and subsurface conditions entails a substantial risk of early failure. Analysis of this experience resulted in development of a detailed set of site assessment guidelines for locating infiltration devices in the future to ensure that soil and subsurface conditions are appropriate for their implementation. It is important that these guidelines be implemented to insure that infiltration is used with adequate separation from groundwater and in soils with a favorable infiltration rate. In addition, loss of soil structure, clogging, and other changes that may occur during the life of the facility may be difficult to ameliorate. Nevertheless, infiltration devices are considered technically feasible at suitable sites and they were among the most cost-effective BMPs tested in this study. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.11.2 Infiltration Basin Model – Effects on Soil and Groundwater

Objectives

The purpose of this study is to model the long-term impact of infiltrating storm water on soils and groundwater. Specifically, the study will ascertain which constituents may leach to groundwater and exceed standards and which constituents may accumulate in the soil and exceed standards. The questions this study hopes to answer are:

- How quickly will the constituents build-up in the soil?
- How often will maintenance be required?
- Will the soil become a hazardous material?
- How deep will the constituents travel?
- Will constituents pollute the ground water?

The study is modifying existing models to predict the accumulation rates, depths, and concentrations of constituents over time. Effects of incidental infiltration through vegetated surfaces, such as biofilters, will also be considered.

Current Status

A preliminary report will be submitted to the Department in Fall 2004. A final report is due Summer 2005.

Findings/Conclusions

None

Available Documents

None

3-Year Action Plan

Overview of Approach

Finish modeling of existing pollutants, including herbicides. Validating the model with experimental data is proposed after completion of the Final Report.

Products and Deliverables

- Interim report.
- Final report.

Schedule

Interim report is anticipated Fall 2004. Final report including herbicide analysis and incidental infiltration is anticipated Summer 2005.

2.12 OIL / WATER SEPARATOR

Oil/water separators typically use baffles to separate floating oil from the water. Oil/water separators are installed below grade. They are typically effective for free oil and grease concentrations above 15 milligrams per liter (mg/L).

2.12.1 BMP Retrofit Pilot Program — Oil/Water Separator

The BMP Retrofit Pilot Program pilot oil/water separator uses coalescing plates to create larger, more separable oil globules from smaller droplets.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance.

Current Status

Study is complete.

Findings/Conclusions

Although an oil-water separator (OWS) was successfully sited, constructed and monitored, the results indicate that this is not an applicable technology for the piloted location. Twenty-two maintenance stations were originally considered for implementation of this technology and the ten with the potential for higher concentrations of petroleum hydrocarbons in runoff were subject to further evaluation. Four of these were subsequently selected for monitoring and of these, only one site appeared to have concentrations that were sufficiently high to warrant installation of an oil-water separator. However, concentrations of free oil in stormwater runoff observed during the course of the study from this site were too low for effective operation of this technology. Runoff quality from three other maintenance stations was monitored during the study and concentrations of petroleum hydrocarbons at these sites were also below the threshold required for effective operation of the oil-water separator. Improved source-control measures at Caltrans maintenance stations have generally been effective in reducing hydrocarbon pollutant levels below that which OWS are effective in removing. In conclusion, none of the 25 maintenance stations in Districts 7 and 11 that were evaluated had sufficiently high concentrations of free oil for successful implementation of this technology. At these low levels, other conventional stormwater controls can provide better treatment of hydrocarbons, as well as other pollutants of concern in runoff; however, they may be appropriate in certain non-stormwater situations (e.g., where source controls cannot ensure low oil and grease concentrations). (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.13 SAND FILTERS

Sand filters treat storm water by sedimentation and filtration through sand. Two types of sand filters are currently being tested: the Austin style and the Delaware style.

2.13.1 BMP Retrofit Pilot Program — Austin-type Sand Filter and Delaware-style Sand Filter

All of the sand filters pilot tested under the BMP Retrofit Pilot Program use sand with an effective size of approximately 0.2 mm (washed concrete sand–ASTM C-33). The Austin-type filters completely capture the typical design WQV in a separate sedimentation chamber and allow the water to filter through the sand bed. The sedimentation chamber and filter dry out between storms. Delaware-style filters have a permanent pool of water in front of the filter to

enhance settling. They are typically constructed below ground along the perimeter of drainage areas. Delaware-style filters are designed on a flow basis, as opposed to a volume capture basis. The Delaware-style sand filter used in this study treated concentrated flow, though the Delaware typically is used to treat sheet flow that enters along the length of the filter.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

The Austin and Delaware sand filters provided substantial water quality improvement and produced a very consistent, relatively high quality effluent. Although the greatest concentration reduction occurred for constituents associated with particles, substantial reduction in dissolved metals concentrations was also observed when the influent concentrations were sufficiently high, contradicting expectations that little removal of the dissolved phase would occur in this type of device. Maintenance of the sand filter beds to alleviate clogging was not excessive at the test sites, and the siting requirements are compatible with the small, highly impervious watersheds characteristic of Caltrans facilities. Consequently, the piloted Austin and Delaware sand filters were considered technically feasible.

The Delaware design incorporated a permanent pool in the sedimentation chamber, which can increase vector concerns and maintenance requirements. The Delaware filter could be applicable at certain sites where an underground vault system is desired or where a perimeter location is preferred, assuming the vector issues associated with the permanent pool are addressed.

Maintenance and operation of pumps at several Austin sand filter sites was a recurring problem. Consequently, other technologies should be considered at sites with insufficient hydraulic head for operation of sand filters by gravity flow.

Future research on construction methods and materials for sand filters is needed to improve the cost/benefit ratio for these devices. In addition, evaluation of alternative media may also allow the targeting of specific constituents or improvement in the performance for soluble constituents, such as nitrate, which are not effectively removed by a sand medium. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CSTW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.13.2 District 2 — Austin Sand Filters

Two different designs exist for Austin type sand filters: so called "separate" and "combined" sedimentation, also known as "full" and "partial," respectively. A separate sedimentation filter has separate sedimentation and filtration basins. The entire WQV is detained in the sedimentation basin and slowly discharged to the filter. A combined sedimentation filter has a combined sedimentation and filtration basin. In this design, the invert of the basin is the filter bed. Both of these designs are being piloted in District 2. The five Austin-type sand filters constructed and monitored in Southern California as part of the BMP Retrofit Pilot Program were all full sedimentation devices. In contrast to the Southern California pilot filters, the District 2 filters have earthen (rather than concrete) sidewalls.

Objectives

These pilots are designed to determine:

- Constituent removal effectiveness for each type of Austin sand filter
- Costs of constructing the full sedimentation Austin sand filter using earthen walls and bottom
- Construction costs and additional maintenance requirements of the partial sedimentation design
- Any additional maintenance requirements and costs for these sand filters in areas with relatively large annual rainfall and freezing temperatures
- Comparison of cost and performance to the Caltrans BMP Retrofit Pilot Program Austin sand filters

Current Status

Water quality monitoring continuing through the 2005/2006 wet season.

Location (Route, RWQCB, District)	No. of Pilots	Status
I-5 PM 25.07, Central Valley, D-2	1	Two seasons of monitoring complete. Monitoring to continue through the 04/05 wet season. Final report anticipated in 2006.
Mt. Shasta Maintenance Station, Central Valley, D-2	1	One season of monitoring complete. Monitoring to continue through 04/05 wet season. Final report anticipated in 2006.

Findings/Conclusions

Performance is similar to the Caltrans BMP Retrofit Pilot Program sand filters.

Available Documents

Department Document No.	Document Title
CTSW-RT-03-038	2002/2003 Monitoring Report, Caltrans District 2 Sand Filter Study.
CTSW-RT-01-086	Basis of Design Report: Austin-type Sand Filter Cold Climate Application in Siskiyou County at the Mount Shasta Maintenance Station. May 2001.
CTSW-RT-01-085	Basis of Design Report: Austin-type Sand Filter Cold Climate Application in Shasta County Adjacent to Interstate 5 near the Mountain Gate Overcrossing. June 2001.
CTSW-RT-01-034	Research Plan for Alternative Configurations and Pretreatment Options for Sand Filters. July.
CTSW-RT-04-128.01.01	Water Quality Monitoring Sampling and Analysis Plan
CTSW-TM-04-128.01.1	Caltrans District 2 Sand Filter Study, Cold Climate Application, End-of-Season Technical Memorandum No. 1

3-Year Action Plan

Overview of Approach

Continue monitoring to achieve higher confidence in performance members.

Products and Deliverables

Final Report on cost, performance, and maintenance Requirements.

Schedule

Continue Monitoring through 2004/2005 and the 2005/2006 wet season.

2.13.3 Tahoe Basin Small-Scale Test Facility — Small-Scale Pilot Studies

Objectives

The Tahoe small-scale pilot treatment systems operate intermittently to treat discrete batches of storm water collected after various runoff events. The objectives of these pilot studies include:

- Testing the effectiveness of sedimentation and sand filtration treatment systems in removing colloidal, dissolved and particulate storm water pollutants
- Developing design parameters for full-scale pilots

Current Status

First season (01/02) monitoring included testing filter systems with one of three different sand media: coarse (~ 1 mm), fine (~ 0.5 mm) and concrete (~ 0.2 mm). Arrangements of coarse and fine sand tested included: direct filtration, direct filtration with filter aid, direct filtration with coagulant and filtration following coagulant and sedimentation. One system tested concrete sand in a simulation of a typical Austin sand filter. Second and third season monitoring objectives included further evaluation of fine sand as well as alternative media.

Location (Route, RWQCB, District)	**No. of Pilots**	**Status**
Meyers Maintenance Station, Lahontan, D-3	2 (Fine Sand)	Third monitoring season (03/04) testing complete. Third monitoring season report expected in 2004.

Findings/Conclusions

First and second monitoring season reports are now complete. First season monitoring showed that the sand filter systems tested were ineffective when used without prior chemical addition and sedimentation. Second and third season monitoring confirmed that sedimentation without chemicals followed by fine sand filtration was ineffective as a treatment system for meeting the numeric discharge limits in the Tahoe Basin.

Available Documents

Department Document No.	Document Title
CTSW-RT-01-054-D	Lake Tahoe Storm Water Treatment Pilot Project Monitoring and Operations Plan. October 2001.
CTSW-RT-03-042	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase I Report.
CTSW-RT-03-053.33.41	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase II Monitoring and Operations Plan. June 2003.
CTSW-RT-03-079.31.37	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Phase II Report.
CTSW-RT-04-069.04.04	Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project Phase III Monitoring and Operations Plan. June 2004.

3-Year Action Plan

Overview of Approach

The study will continue with media that has shown the most promise based on past results. Both 4-inch and 30-inch columns will be used to test removal efficiencies for different concentrations, chemical additions, media, detention times, and volumes treated.

Products or Deliverables

- Reconnaissance study or other literature review reports
- Site-specific Monitoring and Operations Plans
- Final reports summarizing and analyzing data collected

Schedule

Monitoring will likely continue for the next three years. Interim reports will document results of major phases of the study that affect future testing and recommendations for full-scale pilot projects.

2.14 TRACTION SAND TRAPS

2.14.1 Tahoe Basin Pilot Program — Double-barrel Sand Traps

Double-barrel sand traps are the most common type of traction sand trap deployed in the Tahoe Basin. They consist of two barrels buried vertically in the ground and connected in series by a pipe. Storm water and snowmelt runoff enters the first chamber and overflows into the second before exiting. The traction sand settles to the bottom of the barrels.

Objectives

These pilots are designed to determine:

- Constituent removal effectiveness
- Size and quality of the captured sediment
- Size and quality of the sediment that escapes

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
HWY 50 PM 67.91, Lahontan, D-3	1	Two years of water quality performance monitoring complete. Final report complete.
HWY 50 PM 74.27, Lahontan, D-3	1	Two Years of water quality performance monitoring complete. Final report complete.

Findings/Conclusions

The sand traps were successful in trapping most of the sand entering them. The only other constituents with significant removal rates were some total metals and TSS.

Available Documents

Department Document No.	Document Title
CTSW-RT-00-039	Sampling and Analysis Plan: Caltrans Tahoe Basin Stormwater Monitoring Program. December 2000.
CTSW-RT-03.054.36.02	Caltrans Tahoe Highway Runoff Characterization and Sand Trap Effectiveness Studies, 2002-2003 Monitoring Report. June 2003.

2.14.2 Tahoe Basin Pilot Program — Sand Trap with Filter Fabric (TR 1000)

This unit is a double-chambered concrete vault consisting of a sedimentation chamber followed by a secondary chamber with filter-fabric-covered outlets. Larger particles settle in the sedimentation chamber and smaller particles are captured by the filter fabric before storm water is discharged.

Objectives

These pilots are designed to determine:

- Sand trapping effectiveness
- TSS and turbidity reduction
- Technical feasibility
- Cost

Current Status

Location (Route, RWQCB, District)	No. of Pilots	Status
SR 267, Lahontan, D-3	2	Under construction. Water quality monitoring scheduled for 04/05 wet season. Final report anticipated in fall 2008.

Findings/Conclusions

none

Available Documents

none

3-Year Action Plan

Overview of Approach

A sampling and analysis plan will be developed. The sand traps will be monitored for three wet seasons. A final report on cost, performance, and maintenance will be written.

Products and Deliverables

- sampling and analysis plan
- annual monitoring reports
- final report

Schedule
Monitoring will begin for the 04/05 wet season.
The final report will be prepared in FY 07/08.

2.15 VEGETATED TREATMENT SYSTEMS

Vegetated treatment systems are also known as biofilters. Treatment occurs by allowing contact between storm water and the grass. Pollutant removal occurs by contact filtration and infiltration.

2.15.1 BMP Retrofit Pilot Program — Biofiltration Strips and Swales

The BMP Retrofit Pilot Program pilot biofilters were designed according to typical design criteria that specify minimum and maximums slopes, channel bottoms and length. Biofilter swales were trapezoidal with a maximum slope of 1 percent. Strips had a minimum length of 8 meters and a maximum slope of 3 percent.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

Biofiltration BMPs, including bioswales and biofiltration strips are considered technically feasible depending on site-specific considerations. Overall, the reduction of concentration and load of the constituents monitored was comparable to the results reported in other studies, except for nutrients. Nutrient removal was compromised by the natural leaching of phosphorus from the salt grass vegetation used in the pilot study. This condition was not known at the start of the project but was discovered later in the program (see Chapter 8 for details). While space limitations in highly urban areas may make siting these BMPs difficult, they are suitable for fitting into available space such as medians and shoulder areas. Their use should be considered where existing space and hydraulic conditions permit.

Although irrigation was used to establish vegetation for the pilot biofiltration swales and strips, natural moisture from rainfall was sufficient to maintain them once they were established. Complete vegetation coverage, especially on the sideslopes of swales, was difficult to maintain, even with repeated hydroseeding of these areas. Lower vegetation density and occasional bare spots are to be expected in an arid climate, but do not appear to seriously compromise pollutant removal. An important lesson of this study is that a mixture of drought-tolerant native grasses is preferred to the salt grass monoculture used at the pilot sites. In southern California, it is preferable to specify species that grow best during the winter and spring (the wet season) and to schedule vegetation establishment accordingly. Few erosion problems were noted in the operation of the sites; however, damage by burrowing gophers was a problem at several sites.

Biofiltration swales and strips were among the least expensive devices evaluated in this study and were among the best performers in reducing sediment and heavy metals in runoff. Removal of phosphorus was less than that reported by Young et al. (1996) but may be related to leaching of nutrients from the saltgrass during its dormant season. The swales are easily sited along highways and within portions of maintenance stations, and do not require specialized maintenance. In addition, the test sites were similar in many ways to the vegetated shoulders and conveyance channels common along highways in many areas of the state. Consequently, these areas, which were not designed as treatment devices, could be expected to offer water quality benefit comparable to these engineered sites. More research is needed to investigate this possibility.

The research needs involving biofiltration devices center on refinement of the design criteria and evaluation of the performance with vegetation other than salt grass. The current design criteria for strips are especially poor with little guidance on the relative size of the tributary area to the buffer strip, and almost no data on the effect of slope and length on removal efficiency. In southern California and other relatively dry climates, it is also important to establish the minimum vegetation coverage needed to provide effective pollutant removal. (Source: Caltrans BMP Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.16 WET BASINS

Wet basins generally are designed deeper than constructed wetlands. Wet basins are commonly designed as capture-and-release devices. Vegetation is optional.

2.16.1 BMP Retrofit Pilot Program — Wet Basins

In the existing pilot, the total basin volume is four times larger than the design storm water quality volume. A permanent pool, fed by perennial flows, occupies three-quarters of the basin volume. The remaining volume is inundated by storm water and released over 24 hours, returning the water level to the pre-storm, permanent pool level.

Objectives

All BMP Retrofit Pilot Program studies are designed to determine:

- Technical feasibility
- Construction costs in the Department's retrofit environment
- Operations and maintenance costs
- Performance

Current Status

Study is complete.

Findings/Conclusions

One wet basin was successfully sited and operated for this study, and observed pollutant removal was substantial. An important finding of this study is that the discharge quality from a wet basin with a large permanent pool volume is largely a function of the quality of the baseflow used to maintain that pool and of the transformation of the quality of that flow during its residence time in the basin. It should be noted that for this specific pilot installation and receiving water (impaired by nutrients), an ancillary benefit was the treatment provided in the wet basin for the 'offsite' base flow and the substantial nutrient reduction observed during dry weather periods.

Depending on site specific information, wet basins are considered technically feasible for highway stormwater treatment; however, there are a number of concerns regarding the applicability of wet basins for retrofit of Caltrans facilities. The long-term maintenance requirements and costs of wet basins may not have been accurately estimated because some major maintenance activities did not occur during the study period. The potential for the basin to become a habitat for endangered species may result in required consultation with the USFWS and subsequent mitigation, should habitat 'take' occur during routine maintenance activities. The cost of these potential mitigation activities also is unknown. Consequently, wet basins

warrant further study to understand the risk and cost of habitat mitigation and other potential impacts of endangered or threaten species issues.

Vector (mosquito) control required additional vegetation management that resulted in observed maintenance that was much higher than for other devices. Vector control experts were only marginally satisfied with the level of vector prevention provided by mosquito fish, although they were generally effective in reducing mosquitoes.

A primary siting constraint of this technology is the need for a perennial flow to sustain the permanent pool. The siting process showed that the vast majority of the pilot BMP locations constructed were in small, highly impervious watersheds with no dry weather flow.

Basin size also limited siting opportunities. With a permanent pool volume three times the water quality volume, the wet basin had as much as four times the volume of other technologies, such as detention basins. The larger size results in higher cost and land requirements higher than those of alternative technologies. Many other criteria for sizing the permanent pool have been recommended, which may reduce the facility size while providing only slightly less pollutant removal.

A number of questions are left unanswered by this study and warrant further investigation. Additional work could help define the relationship between permanent pool volume, construction cost, and water quality benefit. An assessment of the feasibility of a seasonal wet basin, where the pool was allowed to go dry during the summer, would increase siting opportunities by potentially allowing siting of these devices where perennial flow is not present. Finally, additional work is needed to evaluate the impact of endangered and threatened species that would be attracted to the basin and affect the maintenance schedule or requirements. (Source: Caltrans Retrofit Pilot Program, Final Report, January 2004, CTSW-RT-01-050).

Available Documents

Department Document No.	Document Title
CTSW-RT-01-050	Caltrans BMP Retrofit Pilot Program, Final Report. January 2004.

2.17 3-YEAR ACTION PLAN SUMMARY

The 3-year plan for the new and continuing pilots studies are summarized below.

Table 2-1. Summary of 3-Year Schedule for Storm Water Treatment Technology Pilot Studies

Technology	Pilot Program	Location (Route or Facility, RWQCB, District)	No. of Pilots	Scheduled Activities		
				2004/2005	2005/2006	2006/2007
Sand Filters - Partial Sedimentation Austin Sand Filter	District 2 – Austin Sand Filters	I-5 PM 25.07, Central Valley, D-2	1	OM&M	TBD	TBD
Sand Filters - Full Sedimentation Austin Sand Filter	District 2 – Austin Sand Filters	Mt. Shasta Maintenance Station, Central Valley, D-2	1	OM&M	TBD	
Various Combinations of Sedimentation, Filtration, Chemical Addition	District 3 - Tahoe Basin Pilot Program	Small-Scale Facility at South Lake Tahoe Maintenance Station	16	OM&M	OM&M	
Activated Alumina Filters (Dual Media Filters)	District 3 - Tahoe Basin Pilot Program	Hwy 50 (Near Meyers)	2	OM&M	OM&M	
Sand Trap with Filter Fabric	District 3 - Tahoe Basin Pilot Program	SR 267 (Near Brockway Summit)	2	OM&M	OM&M	
GSRD – Reverse Sloping Screen	District 7 - GSRDs	SR-91/Ardmore, Los Angeles, D-7	1	OM&M	TBD	
GSRD - V Screen Conf. 2	District 7 - GSRDs	I-405/Leadwall, Los Angeles, D-7	1	OM&M	TBD	

				Scheduled Activities		
GSRD – Inclined Screen Conf. 4	District 7 - GSRDs	I-210/Christy, Los Angeles, D-7	1	OM&M	TBD	
GSRD - Continuous Deflection Separators	District 11 - CDS	SR-56, San Diego, D-11	2	TBD	TBD	
Bioretention	District 12 SR73 Pilot Program	SR 73, Santa Ana, D-12	1	OM&M	OM&M	
Bioretention	District 4 SFOBB Replacement Project	I-80/ I-880/ I-580/ Toll Plaza, San Francisco, D-4	2	Design	Construction	OM&M
Detention Basins – Bypass	District 12 SR73 Pilot Program	SR73, San Diego and Santa Ana, D-12	4	OM&M	OM&M	
Detention Basins – Overflow	District 12 SR73 Pilot Program	SR73, Santa Ana, D-12	4	OM&M	OM&M	
Detention Basins - Semi-Batch	District 12 SR73 Pilot Program	SR73, San Diego, D-12	4	TBD	TBD	
Detention Basins - Floating Skimmer Outlet	District 12 SR73 Pilot Program	SR73, San Diego, D-12	3	OM&M	OM&M	
Detention Basins – Alternative Inlet	District 12 SR73 Pilot Program	SR73, San Diego, D-12	3	OM&M	OM&M	
Compost Storm Filter	District 12 SR73 Pilot Program	SR-73 San Diego, D-12	3	TBD	TBD	
GSRD - Inclined Screen Conf. 3	District 12 SR73 Pilot Program	SR-73, Santa Ana, D-12	1	OM&M	OM&M	
GSRD - V Screen Conf. 2	District 12 SR73 Pilot Program	SR-73, Santa Ana, D-12	1	OM&M	OM&M	

				Scheduled Activities	
GSRD - Conceptual Design Under Preparation	District 12 SR73 Pilot Program	SR-73, San Diego, D-12	1	OM&M	OM&M

GSRD: Gross Solids Removal Device
SR: State Route
TBD: To be determined
OM&M: Operation, Maintenance and Monitoring
PM: Postmile

This section provides a brief summary and status of erosion control reconnaissance studies and ongoing pilot studies conducted by the Department during the past year.

3.1 PREVIOUS STUDIES

Results of erosion control studies completed prior to July 1, 2003 are summarized in the following reports:

- Temporary Non-Vegetative Soil Stabilization Evaluation Study for 2000-01 Season, October 2001, CTSW-RT-01-066
- Caltrans Hydraulic Application Study, June 2002, CTSW-RT-02-035
- Erosion Control New Technology Report, June 2003, CTSW-RT-03-049
- District 7 Erosion Control Pilot Study, June 2000, CTSW-RT-00-012
- Statewide Erosion Control Review, February 2002, CTSW-RT-01-067

3.2 LITERATURE SEARCHES AND RECONNAISSANCE STUDIES

Initial BMP selection is based on information gathered from various sources, including literature searches. Full details on the process of selection and evaluation of erosion control BMPs are given in the Department's Erosion Control New Technology Report, June 2003 (CTSW-RT-03-049). The Department will assess new practices and products with the following possible outcomes: where sufficient information exists, designate a specific practice or product; for promising technologies, commission pilot studies to determine the effectiveness and applicability to conditions at the Department's facilities; or reject practices and products that do not achieve desired results or do not meet the Department's criteria. Erosion control effectiveness is the ability of the BMP to reduce soil erosion relative to the amount of erosion measured from the bare soil.

3.2.1 Reconnaissance Studies

There were no reconnaissance studies or new technology reports on erosion control performed in the last reporting period.

3.3 PILOT STUDIES

3.3.1 District 5 Vegetation Establishment Maintenance Study (VEMS) (Ongoing)

Objectives

The purpose of this project is to identify vegetation, which is both fast establishing and demonstrates long-term effectiveness in preventing erosion using simulated rain to mimic rainfall patterns in various Department Districts. This project also incorporates the development of a GIS-based guide, which will assist in the selection of vegetative seed species for use in specific areas and climates to increase successful revegetation efforts on highway slopes. A guide has been established for the Department, District 5, representing the California Central Coast. Future plans include generating guides for remaining Districts to assist in the selection of vegetation for roadside stabilization.

Status

Location (Route, RWQCB, District)	No. of Pilots	Status
California Coast, D-5	1	Limited phase completed. Seed mix and vegetation establishment summary.

Findings/Conclusions

A report presenting the interim results is complete. Preliminary results indicate vegetation flats on the top and toe performed the best by reducing runoff by 80 percent and sediment load by 99 percent when compared to no treatment. Hydroseeding alone produced the most overstory cover while seeding on compost produced the most understory cover. There is a much stronger relationship between increased understory cover and sediment reduction, versus increased overstory cover and sediment reduction. Flats on the top and toe with hydroseeding alone produced the most total vegetative cover. Jute with seed on compost yielded significantly less total runoff and jute with seed or compost removed significantly more sediment from runoff than other erosion control treatments. Jute inhibited desirable vegetation when compared to applications with no erosion control treatment. 5.08 cm (2-inch) of compost inhibited undesirable cover, and inhibited desirable cover if seeded beneath the compost. Flats on the top and toe, when combined with jute netting and hydroseeding applied mid-slope, should perform the best for encouraging native plant establishment and minimizing soil erosion. A paper based on the results of this study received the "Most Distinguished Technical Paper Award" for 2004 by the International Erosion Control Association.

Available Documents

Department Document No.	Document Title
CTSW-RT-02-052	Rainfall Simulation: Evaluating Hydroseeding and Plug Planting Technologies for Erosion Control and Improved Water Quality, September 2002

3-Year Action Plan (Seed Mix and Vegetation Establishment Summary)

Purpose

The Seed Mix and Vegetation Establishment Summary is a continuation of the VEMS. The purpose is to develop guidance for effective establishment and maintenance of erosion control vegetation for short-term first growth and for long-term establishment. The vegetation examined in this study will include both native and non-native species. The Department will use the results of this study in an effort to decrease erosion and thereby improve water quality. There is a need to address both vegetation establishment and regular maintenance needs, including time of year for planting, plant selection, soil stabilization, and vegetation needs throughout the lifecycle. Performance criteria include stabilization within 30 days and mature, stable vegetation in one to three years.

Overview of Approach

Tasks in this study include:

1. Develop Vegetation Establishment guidelines: Create District-level guides to plant species useful in hydroseeding slopes for short-term stabilization and long-term cover to minimize soil erosion
2. Run Preliminary Testing: Using the Department's District 5 parameters, run rainfall simulations to develop baseline conditions
3. Develop Plan for Statewide Testing: Apply baseline findings to develop testing strategy for vegetation establishment in other Department Districts
4. Final Report: Summarizing and evaluating data collected at each site

Product or Deliverables

- Draft Report
- Final Report

Schedule

FY 2004-2005 Develop District Level Guidelines the Department's other Districts as appropriate. Conduct monitoring, and document activities and results in post-storm technical memoranda.

FY 2005-2006 Develop District Level Guidelines for the Department's other Districts as appropriate. Conduct monitoring, and document activities and results in post-storm technical memoranda.

FY 2006-2007 Prepare Final Report.

3.3.2 Soil Resource Evaluation Process (Ongoing)

Objectives

This study creates a site evaluation tool that will present revegetation recommendations for large projects. The tool will assist landscape architects, civil engineers, and material engineers in assessing soil characteristics that affect revegetation. The tool guides the user through a seven step process to evaluate a project site. The tool will generate revegetation recommendations based on the information from other erosion control studies. This study considers how information from past studies can improve site evaluations to allow better recommendations for revegetation. The user inputs site characteristics that may affect revegetation success. Based on the input, the tool will offer several options that may correct deficiencies for plant establishment. The tool is expected to have statewide applicability for projects large enough and harsh enough to benefit from a more thorough and systematic evaluation. Examples of successful treatments are expected to be applicable to many other future construction sites, even without site-specific evaluation.

The tool will specifically use information from the study Use of Organic Amendments for Revegetation of Disturbed Sites with Adverse Soil (ongoing see Section 3.3.4). The end product is a flow chart of assessment steps and a CD that contains the program that gives revegetation recommendations.

Status

Location (Route, RWQCB, District)	No. of Pilots	Status
HWY 101, near Willits, Mendocino Co., D-1	1	User guide under development.
HWY 299, Buckhorn summit, Shasta Co., D-2	1	User guide under development.
I-80, near Blue Canyon, Placer Co., D-3	1	User guide under development.

Findings/Conclusions

This project is ongoing.

Available Documents

Final report is expected in Summer 2006.

3-Year Action Plan

Product or Deliverables

The following comprise the deliverables for this study:

- CD for systematic evaluation of soils on drastically disturbed sites
- One page flow chart linked to an interactive CD
- Develop and Perform related training for the end users
- Final Report

Schedule

FY 2004-2005	continue effort
FY 2005-2006	continue effort
FY 2006-2007	complete deliverable

3.3.3 Use of Mycorrhizal Fungi in Erosion Control Applications (Ongoing)

Objectives

This study investigates the relationship of plant species used for revegetation with mycorrhizal fungi. These are soil-dwelling fungi that occur naturally, and form symbiotic relationships with plant roots. The fungus provides improved plant access to nutrients, and this symbiosis enhances the survival of both plant and fungus. The benefits to native plants are of particular interest. Although the fungus occurs naturally in native soils, it is largely absent in highway embankments or cut slopes. Commercial products containing live fungal propagules are available to support revegetation efforts. The project consists of greenhouse plot experiments and field trials in Irvine under natural climate conditions. The study is expected to have statewide applicability.

Status

Location (Route, RWQCB, District)	No. of Pilots	Status
UC Irvine	1	Reporting.

Findings/Conclusions

Study is complete. Final Report is in peer review. Results show that native plants are more dependent than exotic plants on the mycorrhizal relationship, and this dependence is expected to boost native plant establishment. The plot results show that native plant material has the ability to out-compete the exotic species when sufficient fungi are present. Moreover, the interaction between mycorrhizal fungi and native plants can improve soil stability more than the interaction of these fungi with exotic species.

Available Documents

The final report is expected in the Winter 2004/05.

3-Year Action Plan

Product or Deliverables

Final Report

Schedule

FY 2004/05 Complete deliverable Winter 04/05.

3.3.4 The Use of Organic Amendments for Re-vegetation of Disturbed Sites with Adverse Soils

Objectives

This study evaluates the use of organic amendments for disturbed sites that are difficult to revegetate. Difficult sites specifically addressed are those with serpentine and granitic soils. The primary method evaluated in the study is mixing urban green waste into the soil. Finite plant material is also being investigated. Finite plant materials are very site specific native plants that only grow on certain types of soil. Some of these plants may successfully revegetate adverse soils. Finite material may be useful for sites where organic amendments are not feasible. The study is expected to have statewide applicability.

Status

Location (Route, RWQCB, District)	No. of Pilots	Status
HWY 20, Colusa Co.	1	Monitoring ongoing
HWY 299, Shasta Co.	1	Monitoring ongoing

Findings/Conclusions

Work is ongoing. Preliminary results show that organic compost can increase revegetation success for drastically disturbed sites where current plant establishment techniques would be unsuccessful. Incorporation of coarse (unscreened) yard waste compost onto erosive, decomposed granite slopes increased infiltration and plant available moisture up to levels of stable, revegetated reference samples. These methods were incorporated into a subsequent project to rebuild the rest of the eroding slope at the highway 299 site.

Available Documents

Final report is expected in Fall 2004.

3-Year Action Plan

Product or Deliverables

Final Report

Schedule

FY 2003-2004 Complete deliverable Fall 04.

3.3.5 Piloting Soil Stabilization: Permanent

Objectives

Purpose

The purpose is to evaluate the performance of non-vegetative permanent soil stabilizers for reducing soil erosion, and the potential impact of these products on storm water quality. The Department has identified the need to assess the potential impact of permanent erosion control measures upon storm water quality. Although numerous products exist for use, the technologies have not necessarily been analyzed, by the manufacturer, for constituent (including sediment) release into storm water. The study is designed to identify, and quantify (if possible) the effect of permanent erosion control materials on storm water.

Examples of products to be identified are:

- Acrylic polymer soil stabilizers
- Soil stabilizing polymer emulsions
- Rock Blanket application (geotextile under a layer of rock obtained from local sources)
- UV-stabilized blankets
- Resin-based soil stabilizers
- Concrete block systems
- Soil cement applications (a native soil and cement mixture)

Overview of Approach

Activities associated with this task will include siting of study sites, construction of test plots within each study site, application of a selected erosion control product to each test plot, and installation of sampling equipment to monitoring storm water runoff from each plot. The monitoring effort will evaluate the potential impact (if any) tested products have on storm water quality.

3-Year Action Plan

Product or Deliverables

- Sampling and Analysis Plans
- Final Report summarizing and evaluating data collected at each site

Schedule

FY 2004-2005 Conduct monitoring and document results.

FY 2005-2006 Conduct monitoring and document results.

FY 2006-2007 Prepare Final Report/

3.4 3-YEAR ACTION PLAN SUMMARY

Table 3-1. Summary of 3-Year Schedule for Erosion Control Studies

Erosion Control Study	Location (Route or Facility, RWQCB, District)	No. of Pilots	Scheduled Activities		
			2004/2005	2005/2006	2006/2007
District 5 VEMS 'Seed Mix and Veg. Establishment'	California Coast, D-5	1	Monitoring	Monitoring	Reporting

Soil Resource Evaluation Process	Various Locations	3	Monitoring	TBD	TBD
Mycorrhizal Fungi in Erosion Control Applications	Irvine	1	Reporting	TBD	N/A
Organic Amendments for Re-vegetation of Disturbed Sites with Adverse Soils	Various Locations	2	Reporting	TBD	N/A
Piloting Soil Stabilization	TBD	TBD	Monitoring	Monitoring	Reporting

This section provides a brief summary and status of characterization studies that were completed or ongoing during 2003/2004.

4.1 PREVIOUS STUDIES

Summaries of storm water characterization and research studies completed by the Department prior to July 1, 2003, are contained in the following reports:

- Discharge Characterization Study Report, CTSW-RT-03-066.51.42
- Caltrans Tahoe Highway Runoff Characterization and Sand Trap Effectiveness Studies, 2002-2003, June 2003, CTSW-RT-03-054.36.02
- Monitoring Report 2000-2001: Caltrans Public Education Litter Monitoring Study, June 2001, CTSW-RT-01-018
- Small Stream Crossing Impact Research Project, North Coast River Loading Project, CTSW-RT-02-040
- Caltrans Construction Site Runoff Characterization Study, September 2002, CTSW-RT-02-055
- Caltrans Drain Inlet Efficacy Study (DICE) Final Report, June 2003, CTSW-RT-03-057.36.1

For each study in this section, reports are listed that should be consulted for additional details. For those studies that are ongoing, a 3-Year Action Plan is provided that addresses tasks and approaches, products or deliverables, and schedules:

4.2 SPECIALIZED CHARACTERIZATION STUDIES

4.2.1 Statewide Toxicity Testing Study

Objectives

The goal of the Statewide Toxicity Testing Research Project is to enable the Department to assess the toxicity associated with discharges from its storm drain system, determine the cause of the toxicity, and provide some understanding of the sources of these discharges.

Current Status

The statewide toxicity study is completed. Currently, the toxicity data are being analyzed and a final report on this topic is expected to be available late 2004. Project was extended to incorporate comments.

Findings/Conclusions

The results obtained from the 2000-01 and 2001-02 wet seasons are summarized below. Toxicity was monitored at four categories of sites; highway drains, maintenance yards, park and ride facilities, and rest areas. In the year 2000-01, 24 highway sites were monitored requiring 278 toxicity tests, four maintenance yards were monitored requiring 65 toxicity tests, 8 park and ride facilities requiring 106 tests, and three rest areas requiring 19 tests (total 39 sites and 465 tests). Of the 39 sites, 23 sites indicated significant acute toxicity. TIEs were performed for 23 sites, requiring an additional 190 toxicity tests.

Each site was tested from one to four times throughout the season resulting in a total of 98 samples tested for toxicity. At least one toxicity test at one sample period (early, mid, and late winter) was significantly different from the control (indicating toxicity) at all but 2 sites. Conversely, 5 sites had dates with no toxicity for any test. Of the three types of toxicity test, the *Pimephales* test resulted in the greatest number of positive test results (significant toxicity) while the *Selenastrum* (algae) resulted in the least number of positive results.

Pimephales – Of the 98 tests performed, 82 (83.7%) indicated significant toxicity for either one or both tests. Significant reductions in biomass were found in 52 samples, and significant mortality was found in 28 samples indicating that most often, reductions in biomass were common and acute toxicity was less common. No pattern in toxicity with respect to date of sampling is apparent as significant toxicity was found at all dates from October to May.

Ceriodaphnia – Of the 98 tests performed, 72 (73.5%) indicated significant toxicity. These results include all tests for which acute toxicity occurred and chronic tests were not possible to perform. As with the *Pimephales* toxicity test results, there appears to be no pattern with respect to date of sampling as significant toxicity was found throughout the entire period of sampling.

Selenastrum – Of the 98 tests performed, 46 (46.9%) indicated significant toxicity. The *Selenastrum* test was never the sole positive test result for any site at any sample date. Again, no pattern in the positive results was evident.

Toxicity Identification Evaluations (TIEs) – Thirty TIEs were performed on samples for which acute toxicity was observed. The TIEs indicated that no single source of toxicity was common among sites. However, nonpolar organic compounds were suggested as the putative source of toxicity in 5 of the TIEs, metals were suggested as the putative source in 11 TIEs, and surfactants were suggested as the putative cause in 7 cases. In one case, a metabolically active pesticide was implicated, and the remainder had no discernable cause.

The results were consistent across years with the samples collected during the 2001-02 exhibiting a slightly higher percentage of toxic samples. In general, the results from the *Pimephales* tests were almost identical in the overall percentage, and the *Ceriodaphnia* tests during 2001-02 produced a slightly higher percentage of tests with toxicity. The greatest difference is in the results of the *Selenastrum* tests performed in both years. Only a small

number of samples were determined to be toxic by the *Selanastrum* test during 2000-01, but almost half of the tests resulted in significant toxicity during 2001-02.

Available Documents

Final report is under preparation. No report document is yet available.

4.2.2 Herbicide Runoff Characterization Study

Objectives

To determine whether best management practices currently employed by the Department during herbicide application adequately protect adjacent surface waters from herbicide runoff, the herbicides oryzalin, isoxaben, diuron, glyphosate, and clopyralid were selected for study to include compounds with significant variation in physical/chemical properties. Concentrations of herbicides in runoff were monitored for up to 11 storms following herbicide application and 24 samples were collected per storm providing unprecedented detail regarding herbicide runoff over multiple seasons at two highway sampling sites.

The primary purposes of this project was designed to: (1) determine the impact of different precipitation intensity, topography, and herbicide properties on herbicide runoff; (2) identify the role of sorption rates in controlling herbicide runoff process and herbicide attenuation with distance; (3) construct a validated model of herbicide fate and transport along highways; (4) test whether herbicides in storm runoff exhibit toxicity toward selected test organisms; (5) study the efficacy of a biomaterial treatment system for removing herbicides from highway runoff; and (6) evaluate the statewide highway roadside configuration, soil properties and their relationship with herbicide runoff.

This is the last year for this project and a final report has been prepared. Followed are the summaries of findings/conclusions from the final report.

Current Status

The herbicide runoff characterization study was completed during 2002-03 monitoring season and currently the data being analyzed and a final report will be available in late 2004. The Draft Final Report is being prepared. Project was extended due to additional analysis and to incorporate comments.

Findings/Conclusions

Major findings and conclusions of this study is summarized below:

Field Observations: The herbicides oryzalin, isoxaben, diuron, glyphosate, and clopyralid were found in the runoff for all monitoring season. Flow-weighted event mean concentrations

(EMC) were calculated for each herbicide in each storm and ranged from below detection limits to 43.13 µg/L. A first order model successfully described the declining herbicide concentrations in spray zone soil and in surface runoff for all sites and herbicides. Fitted first order coefficients were always higher for runoff than for soil indicating that the herbicide that persists in the source zone becomes less available for runoff as the time since application increases. The loading percentage of the applied herbicide that was detected in surface runoff over a season ranged from 0.05 to 43.5 percent and the most critical variables in controlling the variation were the solubility of the herbicide and the runoff volume. For a given herbicide and site the most critical factors in determining seasonal herbicide loss to surface water were the timing and intensity of the first storm following application, affecting total seasonal runoff by up to two orders of magnitude. Minimizing runoff of herbicides along highways will thus require careful attention to the intrinsic mobility of the compound and the timing of its application.

Sorption Control*:* This study examined the sorption and desorption of five herbicides with a wide range of properties (isoxaben, oryzalin, diuron, clopyralid, and glyphosate) on soil samples from two roadsides, and used the results to examine field runoff data from multiple rainy seasons. Nonideal sorption processes do not appear to be significant in determining herbicide runoff at the field sites and linear equilibrium adsorption/desorption models are adequate for predicting the concentration of herbicides in runoff in these field settings. The herbicides were highly attenuated when runoff water ran along the vegetated roadside slope.

Modeling: A model was developed to simulate the transport of roadside-applied herbicides in overland and subsurface flows, considering advection, dispersion, linear equilibrium sorption reactions, and a rate-limited mass exchange between soil and overland flow that is assumed to be affected by both sheet flow sheer stress and raindrop impact. It provided good agreement between the measured and predicted concentrations averaged over a storm event (EMCs). The model also provided adequate independent predictions of the remaining herbicide concentration in source zone soil. The modeling exercise suggested that the soil water distribution coefficient, K_d, and the rain intensity are the most important factors in determining the peak herbicide concentrations in runoff.

Toxicity Test**:** The highest concentrations of herbicides found from the two monitoring stations ranged from 10 µg/L for glyphosate and diuron to as high as 200 µg/L for oryzalin. To test whether these herbicides at the highest concentrations can cause any toxicity to organisms, three different toxicity studies were conducted and results showed: (1) 8-day Ceriodaphnia (water flea) toxicity test: no significant reduction in production or increase in mortality relative to the control blank; (2) 7-day Pimephales (fish) toxicity test: no significant increase in mortality or decrease in biomass when compared to the blank control; and (3) 96-hr *Selenastrum* (algae) toxicity test: both 10 µg/L diuron treatment and 50 µg/L isoxaben & 200 µg/L oryzalin treatment had significant ($p < 0.01$) reduction in algae growth compared to the laboratory control.

Treatment Study: In order to remove herbicides from the runoff waters, shredded Cedar mulch was selected as a treatment material. The herbicides of diuron, isoxaben, oryzalin, and clopyralid were used for a laboratory and field treatment study. Both batch and column studies indicated that the mulch had a high sorption capability for the hydrophobic herbicides of

oryzalin, isoxaben, and diuron, but not for water soluble herbicide clopyralid. A field study showed that the initial herbicide peak concentration was attenuated by the shredded mulch. Overall t-test for total 11 storm events did not show any significant removal by mulch treatment. Further field and pilot testing is needed for designing an efficient and more reliable treatment system.

Application: Herbicide runoff is highly dependent on highway configurations. For the purpose of reducing herbicide runoff concentration in receiving water bodies, the best road configuration should be a convex road configuration with berm and long vegetative roadside slope, which usually warrants the least runoff passing through the spray zone, a high attenuation by slope, and a high dilution by the runoff from highway road and roadside slope. Highway roadside soils were found to have a high fraction of rock/gravel (averagely 33.4%) in their composition. Since herbicides usually are not adsorbed on rocks/gravels, a large percentage of rock/gravel means that more herbicides have the potential to be washed by runoff. Herbicide sorption coefficient is the most important factor that controlled herbicide loading in highway runoff. Herbicides with a high solubility often correspond very well with a low sorption coefficient for the 33 herbicides used by the Department except for glyphosate. A high soluble herbicide like clopryalid was nearly not sorbed by soils, which may result in the worst herbicide runoff case. Because of this, a special attention should be paid to the high mobile herbicides including ammonium sulfate, cacodylic acid, chlorsulfuron, clopyralid, dicamba, diglycolamine, diquat, magnesium chloride, methylarsonic acid, sethoxydim, tebuthiuron, and triclopyr.

Available Documents

Final report is under preparation. No report document is yet available.

4.2.3 California Toxics Rule (CTR) Characterization Study

Objectives

In Spring of 2000, the US Environmental Protection Agency promulgated new ambient water quality criteria for California known as the California Toxics Rule (CTR). Numerical standards were established for 100 constituents, many of which have not been previously studied in highway runoff. Objectives for this project, being conducted by the University of California, Davis, include (1) developing cost effective sampling and analytical strategies to attain the low detection limits required under the CTR, (2) identifying constituents that exceed the CTR limits in runoff from Department facilities, (3) engineering mitigation strategies for problematic compounds

Current Status

The final report is under preparation.

Findings/Conclusions

Principal findings of the CTR study are summarized below:

Inorganics: All species were detectable with our techniques, and based on their concentrations, metals can be classified into three groups: far below all criteria, of possible concern, and definitely having exceedances. First, dissolved concentrations of Be, Cd, Hg, Ag and Tl were very low and always far below all CTR criteria. Arsenic (As), Chromium (Cr) and Lead (Pb) were found at moderate concentrations but never exceeding a CTR limit. (Moreover, Cr was sufficiently low that no exceedance for the hexavalent form was possible.) However, Nickel (Ni), Copper (Cu) and Zinc (Zn) were consistently found at substantial levels. They surpassed the CTR continuous limit (and sometimes the acute maximum criterion) either in some (Ni), most (Zn) or all (Cu) of the storm water runoff samples. The higher maintenance yard Zn concentrations presumably arise from the abundant zinc-coated (galvanized) materials stored there. Data from the second year are similar.

Cyanide measurements exceeded the lowest CTR standard, for discharges to saltwater, in some samples. Investigations of these observations continue to rule out any possible interferences. Also, asbestos fibers are definitely not of concern for highway run-off.

In addition, it seems that total suspended solids (TSS) and dissolved organic carbon (DOC) are important factors in controlling the concentrations of dissolved metals in storm water runoff. There was a significant correlation between the concentrations of dissolved metals and TSS, indicating that TSS in storm water runoff was an important source of metals in dissolved form. Also there was a strong correlation between the concentrations of dissolved metals and DOC, suggesting the importance of DOC in complexing metals and making them more mobile in storm water runoff. Further analyses continues for un-filtered samples.

Organics: It is convenient to summarize the situation by chemical classes of analytes, even though the CTR list itself is not generally organized by type of compound.

Detectable concentrations of volatile organic compounds (VOCs) were found, in some cases relatively close to those CTR criteria where the latter are exceedingly low, such as 1,1,2,2-tetrachloroethylene. In these cases, the ability to produce a very low field blank is the limitation. Benzene, a molecule of heightened awareness, reached a high of only ¼ of the lowest criterion.

For several classes of semi-volatile compounds, concentrations were seen above at least one CTR criterion. In the phenol group, pentachlorophenol was detected consistently at both sites at levels slightly exceeding the lowest CTR limit.

Among organo-chlorine compounds, lindane and heptachlor were detected above CTR limits at the maintenance yard for several events. In addition, 3 legacy insecticides were sometimes found in highway run-off above a criterion: DDT/DDE, chlordane and beta-endosulfan (the latter, only once so far).

A few polycyclic aromatic hydrocarbons (PAHs) were found to exceed criteria at least once in the highway runoff: benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, and dibenzo(a,h)anthracene

Five phthalate compounds are listed in CTR. One (diethylhexyl, or DEHP) has quite a challengingly low criterion. Another, butylbenzyl, was seen nearly up to the lowest criterion for a few storms.

It was noteworthy that some of the highest concentrations observed were during or after the middle of winter – for example following a multi-week period without storms, and from the run-off of a smaller event that provides less dilution. The total mass loading from small storm events is probably not higher than larger storms, because small storms correspond to smaller total volumes of runoff. Second-year results were flow-weighted to improve these estimates.

Available Documents

This study is still ongoing and Draft Final Report under preparation. Completion of Draft Final Report expected Spring 2005.

3-Year Action Plan

Tasks/Approach

1. Develop sampling strategy and required analytical methods
2. Test sampling and analysis methods at representative Department facilities
3. Refine and perfect procedures and techniques
4. Prepare final report

Product or Deliverables

Draft and Final Reports summarizing and evaluating data collected with regard to project goals

Schedule

FY 2004-2005 A final report will be expected Spring 2005.

4.2.4 First Flush Characterization Study

Objectives

The goal of this study is to identify constituent concentration variability with relation to storm intensity, duration and antecedent weather patterns. The data collected will be used to develop pollutographs and, potentially, to design BMPs to remove large fraction of pollutant mass load within a smaller drainage areas. Information on the spatial and temporal distribution of contaminant concentrations in storm water runoff is lacking. Of particular importance is the

relationship between the periodic dry season deposition of contaminants, storm intensity and duration, and the contaminant concentrations in storm water runoff.

Current Status

A final report documenting all findings of this study will be available in Spring 2005.

Findings/Conclusions

1. Most of the water quality parameters associated with highway runoff show a first flush with 20 to 50 percent of the pollutant mass in the first 10 to 30 percent of the runoff.

2. Preliminary particle measurements show that 97 percent of the particles are smaller than 30 mm.

3. The particles tend to aggregate with time, suggesting a natural coagulation/flocculation phenomena.

4. Comparison of the computed EMC from grab samples, as part of the first flush characterization study, with the EMC of automatic composite sample confirmed the suitability of automatic sampler for collecting a representative runoff samples.

Available Documents

Department Document No.	Document Title
CTSW-RT-99-074	Caltrans First Flush Study Sampling and Analysis Plan, November 1999
CTSW-RT-00-016	First Flush Study 1999-00 Report, June 2000
CTSW-RT-00-044	Sampling & Analysis Plan, Caltrans 2000-01, First Flush Characterization Study, December 2000
CTSW-RT-01-037	Summary Report Caltrans 2000-01 First Flush Characterization Study, July 2001
CTSW-RT-00-044U	Sampling & Analysis Plan, Caltrans 2000-01, First Flush Characterization Study, October 2001

Department Document No.	Document Title
Unpublished annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 1, 1999-00
Unpublished annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 2, 2000-01
Unpublished annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 3, 2001-02
Unpublished annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 4, 2002-03
Annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 1: 1999-00
Annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 2: 2000-01
Annual summary report-Department report No. not available	First Flush Analysis of Highway Runoff, UCLA, Year 3: 2001-02

3-Year Action Plan

Tasks/Approach

1. Prepare draft and final report

Product or Deliverables

Draft and Final Reports summarizing four years of highway runoff first flush characterization data.

Schedule

FY 2004-2005 No monitoring is scheduled during this monitoring season. The project is continued principally for data analysis and the preparation of final report.

4.2.5 Pathogens Characterization Study

Objectives

A sensitive method for the detection of pathogens in environmental water has been developed, using *Salmonella enterica* serovar *typhimurium* as a model organism. The method involves the hybridization in solution of target DNA with biotin-labelled capture probes, followed by binding the hybrid to streptavidin-coated magnetic beads. The high affinity between streptavidin and biotin makes this specific binding possible. The application of a magnetic field to this complex permits the separation of target DNA from a complicated matrix that may contain PCR inhibitors and non-target DNA, thus increasing the sensitivity of the assays and decreasing the detection limits. The detection and quantification of the DNA was performed by real-time PCR. Since the recovery of target DNA using the beads was around 50 percent, a statistical procedure was used to calculate the actual pathogen concentration in the original sample from the measured values.

Since pathogens associated with storm water discharge may be present in low concentrations, an effective filtration step is necessary. Previous work with adsorptive filters revealed poor recoveries of virus in storm water. Other researchers have had similar difficulties when using such electrostatic charged filters. An extensive literature review of filtration methodologies showed that filtration based on size exclusion seemed to be less susceptible to interfering compounds. A hollow fiber unit (tangential filtration flow) was selected, which according to other researchers result in consistent recoveries in the range of 70-80 percent when applied to complex water samples.

This work requires sampling in various geographical locations in California, so a portable filtration apparatus is needed. Such a design will enable the filtration and concentration on site of large volumes (up to 100 liters) of water that will be preserved and analyzed back in the laboratory. A first design of the process unit and its quotation were evaluated, and because of the high cost resulted in a second design that led to the apparatus currently being built.

Human adenovirus and enterovirus are two epidemiologically important viruses associated with water that has been contaminated by human waste. Previous studies have demonstrated that these two virus groups may be more prevalent in storm water, or may simply persist longer in the environment. The quantitative detection of these viruses will be done using real-time PCR, and reverse-transcription (RT) PCR. Specific primers and probes for the amplification of both viruses are currently being developed. The design of primers and optimization of the PCR reactions are crucial to the success of the assay.

Since the viruses will be concentrated from large volumes of water, it is critical to determine the efficiency of filtration for each sample. This is accomplished by spiking a known amount of a benign surrogate virus into the water. For this study, the bacteriophage PP7 was selected because of its similar behavior to human enteroviruses during hollow-fiber filtration. Inclusion of this virus in the assay also requires the design of proper probes and primers for quantitative PCR detection and the optimization of the reaction. To have an accurate measure of virus recovery, PP7 viral particles will be enumerated using PCR, rather than traditional culture-based

plaque assays. The PP7 viral particles are quantified by first synthesizing cDNA from the RNA. The cDNA is subjected to quantitative PCR, and the amplification products then cloned into plasmid DNA that is quantified again by PCR. This process of cloning nucleic acid and quantification is also being done for adenovirus and enterovirus.

In addition to the above viruses, bacterial indicators (total coliform and fecal coliform) and the intestinal organism *Escherichia coli* will be monitored using the membrane filtration method according to EPA's *Guidelines Establishing Test Procedures for the Analysis of Pollutants; Analytical Methods for Biological Pollutants in Ambient Water; Final Rule* (July 2003). Training and preliminary preparations are under way to complete these tests by graduate students at the university.

Current Status

Continue to improve PCR technique and sample analysis for storm water runoff.

Findings/Conclusions

Results obtained to date from this study are summarized below:

- The detection of *Salmonella enterica* serovar *typhimurium* with the method developed was successful.
- The principle of the method may be extended to any bacterial, protozoal, or viral pathogen of interest by designing the appropriate probes and primers and optimizing reaction conditions.
- Specific probes and primers for quantitative PCR detection of PP7 were designed and the amplification reaction was optimized. The first Taqman assays were successful for both RNA and cDNA.
- This study does not address the ability of treatment BMPs to reduce pathogens.

Available Documents

Department Document No.	Document Title
CTSW-RT-02-025	Pathogens in Urban Drainage: Results of Investigations of the Presence of Human Pathogens in Urban Storm Drains, March 2002.

3-Year Action Plan

Tasks/Approach

1. Improve and develop new technique for pathogen detection
2. Develop sampling technique for pathogen detection
3. Collect runoff samples from Department facilities and analyze the samples for pathogens using the methods developed as part of the study goal.
4. Prepare draft and final report

Product or Deliverables

Draft and final reports summarizing analytical procedures all test results.

Schedule

FY 2004-2005	Continue improving the analytical and pathogen detection procedure. Monitor Department highway and other facility's runoff. Expand partnership with other municipalities.
FY 2005-2006	TBD
FY 2006-2007	TBD

4.2.6 District 7 Drain Inlet Cleaning Efficacy Study (litter only)

Objectives

The goal of this project is to determine whether drain inlet cleaning impacts the water quality of storm water runoff from the Department's highways. Both water quality and litter were monitored as part of this study. Sufficient water quality data were obtained for over four years and a comprehensive report was prepared on this topic. Litter, however, was monitored for only one year. It is planned to monitor litter at DICE sites during the 2004/05 wet season. The Final Report does not include this final phase of litter monitoring. The report reference is CTSW-RT-03-057.36.1.

Current Status

Monitoring is continuing only for litter.

Findings/Conclusions

The results indicate that there was no significant change on water quality among those sites that were cleaned compared to those that no cleaning was performed.

Available Documents

Department Document No.	Document Title
CTSW-RT-03-057.36.1	Drain Inlet Cleaning Efficacy Study, June 2003

3-Year Action Plan

Tasks/Approach

Complete final year of litter monitoring

Product or Deliverables

Draft and final reports summarizing all results of monitoring

Schedule

FY 2004-2005 Finish monitoring litter and prepare final report.

4.3 3-YEAR ACTION PLAN SUMMARY

The 3-year plan for the new and continuing pilots studies are summarized below.

Study	Location (Route or Facility, RWQCB, District)	Scheduled Activities		
		2004/2005	2005/2006	2006/2007
Statewide Toxicity Study	Various	Reporting		
Herbicide Runoff Characterization Study	HW 101 PM 52.25 (Humboldt County), North Coast, District 1; HW 37 PM 2.9 (Sonoma County), San Francisco, District 4	Reporting		

First Flush Characterization Study	6 freeway locations, Los Angeles, District 7	Reporting
California Toxics Rule Characterization Study	Various	Reporting
Pathogens Characterization Study	UC Davis	Method improvement & reporting
District 7 Drain Inlet Cleaning Efficacy Study	8 freeway locations in District 7, Los Angeles	Monitoring & reporting

Caltrans, 1999. National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharge from the State of California, Department of Transportation (Caltrans) on Properties, Facilities and Activities.

Caltrans, 2003. Statewide Storm Water Management Plan. May 2003. CTSW-RT-03-008

APPENDIX A *Monitoring Protocols and Tools*

Over the last several years the Department has implemented an impressively diverse and intensive storm water monitoring program. Much effort has been invested into ensuring that the monitoring data produced by the Department's storm water monitoring program will be scientifically defensible. As a result the Department has developed the following manuals and software tools:

- Comprehensive Monitoring Protocols Guidance Manual
- Data Reporting Protocols
- Automated Data Validation (ADV) and Laboratory EDD Error Checker
- Hydrologic software utility
- Data analysis toll
- Master Stormwater Database

The above manuals and software tools are available through an electronic tool box (CTSW-OT-03-002) and mandated its use by all monitoring teams collecting data. The application of each manual and software tool is briefly described below.

Comprehensive Monitoring Protocols Guidance Manual

This Comprehensive Manual is a compendium of individual Guidance Manuals covering each of the four types of monitoring conducted under the Department's Storm Water Monitoring and Research Program: Stormwater Runoff Water Quality Monitoring, Particle/Sediment Quality Monitoring, Litter Monitoring, and Toxicity Studies.

A technical committee was established to guide production of each of the individual subject area Guidance Manuals, led by experts experienced in the field. The principal aims of the Guidance Manuals are to:

- Ensure consistency in monitoring methods throughout the state
- Specify scientifically-sound sampling and analytical techniques
- Minimize contamination of environmental samples
- Produce data of verified quality

The *Guidance Manual: Stormwater Monitoring Protocols* (Caltrans, 2000), which contains the runoff water quality protocols, is available on the Department's Storm Water Management Program web site: http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/index.htm

Data Reporting Protocols

To ensure informality, the Department has established data reporting protocols in Excel format. Entries into data fields were standardized for both analytical and non-analytical data. The data reporting protocol provide detailed specifications for data fields and instructions for content. The protocols help ensure that data from all projects will be reported in consistent format – and that the data records will include sufficient information to permit their full use within the Department's Storm Water Database. Once Excel spreadsheets are reported to the Department according to data reporting protocols, data are imported into an access database that holds statewide monitoring data. These data are extracted for statistical analysis and data evaluation.

Automated Data Validation (ADV) software

A thorough data quality evaluation is performed following receipt of the laboratory data, in which the results of QA/QC sample analyses are compared to the project's data quality objectives, and suspect data are qualified (flagged) as necessary, following guidelines established by the United States Environmental Protection Agency (EPA) for evaluation of inorganic and organic analyses.

The automated program permits quick and efficient evaluation of lab data against data quality objectives and standard measures of data quality, and provides extensive error-checking for a standard set of possible analytical or data transcription errors. The resulting electronic data deliverable (EDD) is then ready for final checking prior to entry into the Department's storm water quality database. The final data validation step involves checking that the EDD conforms to the Department's Data Reporting Protocols for the specific data type; corrections are made as necessary to provide information for any missing or improperly-populated data fields.

Hydrologic software utility

This software assists monitoring managers in determining whether the sample representativeness criteria have been met for a given monitoring event. The purpose of the Department's Hydrologic Utility is to standardize consultant calculation of important storm and sampling parameters, such as total flow volume, total event rain, estimated percent capture, and others. In addition, the utility generates a hydrograph and a hyetograph from measured hydrologic data.

The hydrologic utility is installed as an "Add In" in Microsoft Excel and is composed of a number of Visual Basic subroutines. The calculations and graphs are created from user-controlled input parameters as well as datalogger exports of rainfall, flow rate, and sample data records. The utility output is in two parts; a new worksheet and a new plot (chart) are added to the workbook. The output worksheet contains the processed input data that acts as the source data for the plot and a summary table of important calculations. The output hydrograph and hyetograph plot notes the timing of the primary composite sample aliquots, when they are provided, and includes a table of important summary data. The plot and the calculated parameters are output to a worksheet page that can be printed and added to event reports. An example of the hydrologic utility output is shown on the following page.

Data Analysis Software Tool

The Department has developed a software tool as a means to efficiently generate descriptive statistics for monitoring data. The DAT can be run on user-selected data sets directly from the database interface screen, or used as a stand-alone Excel Add-In. The DAT employs a Regression on Order Statistics (ROS) technique for appropriate statistical treatment, including handling of non-detect data. This tool uses the detected values and a combination of regression and probability analysis to determine a "fill-in" concentration value to assign to all data points below the reporting limit (non-detects), based upon an assumed log-normal probability

distribution The filled-in values are then used in statistical analysis. An example of the output from the DAT is shown on the following page.

Master Stormwater Database

Once the error-checking and data validation process is complete, EDDs (in the form of Excel spreadsheets) are delivered to the Department, and the data is imported into an Access database. Data are stored in three main tables: sample description, event description, and site description. The fields and content guidelines for each of these tables are described in the Data Reporting Protocols for each category of data (runoff water quality, particle/sediment, litter, toxicity). The Department's Storm Water Quality Database includes a user-friendly interface with a GIS-based map feature and menu-driven query screen. This interface permits quick and easy retrieval of data based on user-selected parameters. A screen shot from this data management tool is shown below.